JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIV.] NOVEMBER, 1867. [No. 5.

EDITORIAL.

SPECIALITIES IN TOOL-MAKING.

IT is no new idea that division of labor and consequent concentration of energy and attention, upon some special process or article, is the sure means to attain the highest degree of excellence in the result combined with the utmost economy in production; but there are some consequences flowing from the practical working of this rule, which may possess sufficient novelty to render them worthy of notice.

At the conclusion of the late war, there were many manufactories of small arms, supplied with every facility for the construction of such work, that were left unemployed, the demand for their products having ceased.

Many of these, very judiciously, turned their attention to the production of a class of small tools for which their peculiar facilities especially fitted them, and we thus have introduced into the market a new class of articles, which in many cases were formerly made for themselves by those who employed them, but which, as thus supplied,

can be obtained at a less cost than that involved in such individual manufacture, with sundry other advantages of completeness and special workmanship, the result of the well-known principle stated above.

We propose at this time, and on subsequent occasions, to give descriptions of certain among these improved tools, and, where it is possible, to enter also into some detail as to the history of their improvement and growth in efficiency.

In our last issue we noticed, among other mechanical novelties, Cooper's improved tool-holder, in which an elastic conical thimble, fitting the tool, was driven into a conical hole in the end of the tool-holder, and thus secured in its hold upon the tool, which was held to its work by that means.

For light cuts this plan appears to be efficient, but when heavy work is required, the grasp thus secured on the tool is not enough and it is pushed through. For these cases, therefore, we have another appliance, or rather modification of the same, in which the tool is made fast by a gibb working in a slot cut in the holder, back of the tool and forced against the latter by a wedge and screw operated from above.

This is the form manufactured by the Cooper & Phillips Tool Co., of Providence, R. I.

The drawback attending this structure is the necessity of overhanging the tool from the slide-rest, to give room for the nut of the set-screw and the bottom of the wedge.

Another modification of the same general plan, by which this last trouble is avoided, seems to reach the limit of simplicity; for the tool is here secured by a wedge placed in a slot behind it, and forced home by a set-screw from above, thus requiring no more overhanging than the slope of the tool itself demands.

These various and ingenious devices are modifications of the old and well-known plan of the split-bar and nipping-screw. We see in them the effect of special application and development.

Another important improvement lately brought to our notice, is a boiler-maker's drifting-tool, which we may describe as follows: On the ordinary conical drift of steel, a very steep thread is cut in one direction and then in the other, thus leaving a series of diamond-shaped projections with oblique cutting edges.

When this tool is driven through the work it makes a perfectly smooth (in fact polished) cut, steadily and without the "chatter" observed with drifting tools, having simple oblique cutting edges such as are generally used.

A tool, identical in principle, has been employed by Mr. Linus Yale, Jr., in his lock manufactory for many years.

In this case, the holes to be cut are rectangular, and a flat bar of steel is employed, grooves being planed obliquely in two directions across its faces, care being taken that the cuts are so adjusted as to preserve a regular series of cutting points at the angles or edges of the bar. This operates precisely as in the former case.

Another excellent device is the ratchet-brace illustrated in Fig. 1. In the turning-block in the head of the ratchet-brace are set a number of bolts sliding in tangential slots, and pressed outward by spiral springs. The corresponding notches in the ratchet-brace are one more in number. Thus, as in the cut, with four bolts, there would be five notches, thus giving a movement equivalent to an ordinary ratchet of twenty teeth. The strain upon the bolts, moreover, is of a shearing character, and their maximum resistance thus comes in play. A ratchet-brace made on this plan need only be three-quarters of an inch thick, measuring through the square hole to which the drill-socket is fitted, and hence can be used in a limited space. The invention also furnishes a tool capable of being made by machinery adapted to gear work. It has been extensively used in England for some time, and is said to be the invention of a Mr. Weston, an American citizen, and we believe has been secured here also.

Fig. 1.

THE PENN SQUARE BUILDINGS.

A GREAT day has dawned upon Philadelphia. It seems as though the light which literature and science shed in former times upon the city was breaking through her sleepy atmosphere, and arousing her men of learning to public manifestations of life. It is proposed to give to her libraries and museums, which have long since grown too great for the clothing of their infancy, enlarged space. At the last meeting of the Councils of the city, the resolution to ask the Legislature to grant the four small public parks or squares, situated at the corner of Broad and Market Streets, and formerly the site of the water-works of Philadelphia, to the following named institutions:

The American Philosophical Society, the Philadelphia Academy of Natural Sciences, the Franklin Institute of Pennsylvania, the Philadelphia and Loganian Libraries and the School of Design, was agreed to without deliberation and without debate. This singular unanimity of action was due, in large measure, to the articles favorable to the matter, which were written by public-spirited men, and published day after day for months past in the newspapers and journals. It shows, in a notable manner, how public opinion may be educated until it grows irresistible, and carries moral inertia and politics before it.

Among the many advantages which will result from this centralization and extension of the institutions of learning in Philadelphia, the following may be suggested:

It will build up in a great city, already enjoying a renown for medical, mechanical and general science, an increased love for such pursuits. It will tend to draw from their self-imposed obscurity a large number of accomplished scholars. The aggregate number of volumes which are collected at present in the libraries of the different academies above-named is 170,000, and when increased facilities are afforded, it is not rash to suppose that this aggregate would soon swell to 300,000, and surpass in extent any other single collection of books in our country.

Such a cluster of buildings, with an unequaled library, a vast storehouse of specimens in natural history, an immense number of models of mechanical inventions, a complete catalogue of philosophical apparatus, great galleries of paintings and statuary, would afford students in every department of literature, science and arts all the facilities requisite to the most elaborate research. Within a compass of 1000 feet square, he will look upon the labors of Audubon and Wilson, Benjamin Franklin and Dr. Robert Hare, and of hundreds of others, who spent their lives, retired from public gaze, in building up these great collections of fossils, minerals, shells, plants and models.

It would afford an opportunity for a division of labor in mental pursuits, which is loudly called for in these times of exhaustive investigation, and would largely tend to the efficiency of the different institutions concerned. The American Philosophical Society, which lately deposited its cabinet of minerals in the Academy of Natural Sciences, might go further, and abandon object studies altogether. It might endeavor to procure for its library all the works relating to the higher mathematics, to astronomy, biology, metaphysics, philology and cognate branches, and no others. It might divide itself into two sections,

as the Astronomical Section, the Biological Section, and so on, which would include as regularly attending members all the citizens of Philadelphia eminent in these particular branches, and as correspondents all the distinguished men in these departments throughout the world. Its *Transactions* would thus secure a large amount of original material for publication.

Once possessed of a building which would occupy any of these squares, the Academy of Natural Science would have accommodations for its rapidly increasing collections. The naturalist might expect to find in it every species, organic or inorganic, of which mention had been made in books, and might proceed with ease and delight to assign to every new specimen, which the collectors of the Academy might discover, its appropriate place.

The mere contemplation of these great things is delightful to the student. He already sees in imagination six or seven buildings of different, but artistically related designs, and planned (as the occasion calls for) by the first architects of our country, rising majestically in the centre of a great city. Through their halls he shall wander for months and years without being able to examine, in the most cursory manner, all the objects gathered there for his instruction. It will be to the lover of the true and beautiful an enchanted land, from which, when he has once fairly breathed its pure air and seen its rich expanse, he will never be able to depart. Students from every State will gather to avail themselves of its benefits. In its fertile soil new arts and sciences will spring up and redeem the science of this country from the European taunt of mediocrity. A. R. L.

THE WILLIAM BUTCHER STEEL WORKS.

PHILADELPHIA has such a quiet way of progressing, that even her adopted citizens assume at once her modesty in advancements. We have at present in our mind's eye the William Butcher Steel Works of Philadelphia. Few of our citizens are aware of the importance of these works to Philadelphia. William Butcher, of the old house of Sheffield, England, whose reputation in the manufacture of steel and various articles of that material is world-wide, is the manager of the Philadelphia works, combining his experience and talents with our superior materials, producing an article inferior to none in the world. Steel, as compared to iron, is as the diamond compared to carbon; in

fact, is not unlike that precious jewel, having its perfection dependent upon the carbon, good steel being proportionately as difficult to produce as the diamond is to procure, a fact which, if it were better understood, would prevent many from attempting this manufacture without the proper experience or knowledge. It is in this particular that we expect the Philadelphia Steel Works to excel, as they are making the steel, as it has been made before, in the Butcher's works at Sheffield, with what additional advantages may exist in our superior ores, coals, &c. The works are situated at the junction of the Reading and Germantown Railroads, and are now in operation, turning out tons of the valuable material daily, in the shape of ingots, railroad frogs and crossings, locomotive tyres, shovel steel, spring steel and a variety of other forgings and castings, together with a neat thread-like article, well adapted to encircle our American damsels in the shape of hoop-skirts. The works rest in an inclosure of some fifteen acres, and consist of five spacious buildings, in which the various processes are carried on, the whole of which is owned by an incoporated company, under the title of the William Butcher Steel Works of Philadelphia. We are indebted to the kindness of Mr. Thomas Shaw, their consulting engineer, for information pertaining to these works.

ENGINEERING ITEMS.

Tunnel under the Indus.—More than five years ago the work of building a tunnel under this river at Attock, was undertaken in accordance with a plan proposed by Col. A. Robertson. After the preliminary drifts from either side had been carried to within 285 feet of meeting, when, owing to insufficient provision for the work, and various accidents, it was abandoned. It is now, however, to be resumed, and if completed, will be the first railway tunnel under a great river.

The entire length of this tunnel will be 7215 feet, its greatest depth below entrance 182 feet, depth of roof below bed of river 20 feet.

The tunnel under the Chicago River is again under way with every chance of a thorough and successful prosecution of the work. From Mr. Chesbrough, City Engineer for Chicago, and originator (as all know) of the famous Lake Tunnel, as well as the plan for raising the entire city, which has been so successfully carried out under his management, we have received the specifications for the work, from which

we learn that the bottom of the tunnel, or top of invert in the middle of the river, is to be 32·4 feet below low water.

The length of tunnel will be 838 feet, with open approaches of 770 feet in all. The tunnel under the river is to consist of three passage-ways, one 10 feet wide for foot-passengers, the others 11 feet each, for vehicles.

Tests of Ransom's patent stone under the British Government, at Bombay, have been made, and, though under very unfavorable conditions as regards the supply of proper material, moulds and knowledge of the manipulation, have resulted in a very favorable report.

Steam rollers for roads.—The employment of these machines in Paris has been noticed before in this *Journal*, and we would now mention that they are also receiving successful appreciation in England.

Some time since Messrs. Easton, Amos and Anderson made a set of rollers for the new park of Mr. Hanbury, which were drawn by a traction engine built by Messrs. Averling and Porter; but, in the course of operation, it was found that the effect produced by the wheels of the traction engine was as good as that of the roller, though the latter weighed fifteen tons. A traction engine, with wheels three feet broad was, therefore, built and used for the purpose. A short time since, another of these engines, or rather steam rollers, was made for the borough of Liverpool, and on its trial, at Hyde Park, was found to operate in the most satisfactory manner. The wheels or rollers of this machine were seven feet in diameter, two feet six inches on the face and weighed nine tons each.

An immense casting.—We find in *Engineering*, page 267, the following interesting account:

Not long since, Sir John Brown and Company of the Atlas Works, Sheffield, required an accumulator cylinder 36 feet in length. The outer diameter was 36 inches, the inner 26 inches, for a 24 inch ram, and the total weight was to be about 25 tons. Several makers tendered for the casting, in four 9 feet lengths; but Messrs. Tannet, Walker and Company successfully undertook to cast it in one. They dug a pit in their foundry-floor 34 feet deep, and built up a mould in strong cast iron boxes, carefully jointed together. The casting was poured so that the lower half rose from the bottom, the upper half being afterwards poured from the top. The ferrostatic head of a column of iron 36 feet high is about one cwt. per square inch; so that the mould had to be very strong. The iron, before entering at the bottom, fell upon a

wrought iron plate, which broke the shock of the fall and secured the steady rise of the metal in the mould. This remarkable work may be compared, with some reason, to a cast iron gun 36 feet long and of 26 inch bore—a gun heavier than the 15 inch Rodman. The casting was completely successful, and the cylinder is now in use at the Atlas Works.

A steam buggy has been running with success, for some time past, on the roads about Boston. It attains considerable speed, and appears to be light and entirely under control of the driver.

The Panama Railway.—The agents of the Panama Railway Company, at Bogota, have obtained a new contract, extending the Company's privileges for ninety-nine years from date thereof, and giving them the Island of Manilla in fee. For this they are to pay one million of dollars down, and one quarter of a million annually thereafter to the termination of the contract.

Bessemer steel rails.—The Terrenoire Company have just accepted an order for two thousand tons of Bessemer steel rails for the France Eastern Railway Company, at the rate of $68.16 per ton delivered at Sairncage, which represents about $67.4½ per ton at the works.

Belgian rails.—The export of rails from Belgium amounted, in the first seven months of this year, to 59,800 tons, as compared with 3600 tons in the corresponding period of 1866. The increase in this year is attributable to the large demands on Russian account. A further order for 20,000 tons of rails for Southern Russia has been received by two firms.

The trade in amber is becoming more extensive every year at Memel. The diggings in the Samlan, the district between Konisberg and the Baltic, recently yielded 5300 pounds in one year.

Supply of gold and silver.—In 1865 the principal gold-producing countries in the world yielded 559,587 pounds troy of gold, and upwards of 400,000 pounds of silver.

Engineering in China.—At Foo Choo-Choo the native junk is fast being superseded by steamers for the purpose of coast traffic, and a private dock has been at work for three years with great success. The British Consel reported to the Foreign Office, in March of the present year, that the Chinese Government have in contemplation the establishment of a school of engineers and the construction of a naval dock-yard. The whole machinery is to be under the superintendence of French officers. The engineering department is to be

under French instructors. This state of things seems to change all the notions commonly entertained about China. Now the government seems inclined to descend from the celestial connections and to adopt the solid advantages of the habitable globe.

They have decided upon placing a light-house upon the "*White Dogs*," at the entrance to the channel of the river, and of constructing a series of beacons of granite and iron at the dangerous spots, the expense to be defrayed out of tonnage dues on foreign shipping, which, it is calculated, will pay the entire cost in two years. This modern innovation is not confined to one port in China; for from *Tien Tsin* comes report of a similar state of things, at the Peiho. Coal of excellent quality abounds in various parts, though the mines are worked, in the rudest possible manner, to a depth of not more than 200 feet, and when water breaks in and gains upon the workmen they have no way of removing it but in buckets, so that the mines frequently have to be abandoned. For further details, see the London *Engineering*, September, 1867.

NOVELTIES IN CHEMISTRY AND PHYSICS.

Sun spots—Spectrum observations of.—The two prominent theories as to the nature of sun spots maintained at the present time, are those of Faye, and of Messrs De la Hue, Stewart and Lowry. The first assumes that the interior of the sun is a nebulous mass of intense temperature, but feeble radiating power, and that in the sun spot we see through an opening, in the surrounding denser and more luminous photosphere, this opening being caused by an upward current which has as it were melted through the outer shell.

The othor theory maintains that the phenomena of sun spots result from the cooling effects of an in-rush of the atmosphere, outside of the photosphere, which is known to be of a lower temperature.

Some observations lately published by Mr. J. N. Lackyer (see *Proceedings Royal Society*, November, 1866, page 256), throw some weight of evidence against the former theory. By projecting the sun's image on a screen, in which is a slit with a spectroscope behind it, he was able to study the relations of spots and the general surface with the latter instrument.

Though the conditions of observation, up to the present time, had not been very favorable, he felt authorized in stating that the spectrum of the spot showed all the absorption bands visible in that of

the surface, and no indication of the bright lines, which might be looked for if it were a mass of incandescent vapor.

Negative Fluorescence and Phosphorescence.—In the *Philosophical Magazine* for August last, we find a translation of a paper on the above subject, published in the *Annalen*, by Prof. C. Bohn.

The subject discussed is the propriety of clarifying *calorescent* phenomena, such as those exhibited by Tyndall, in his late lectures on radiation, *i. e.* the rendering luminous platinum foil by invisible rays of heat, with those of fluorescence, &c.

Fluorescence, as is well known, is a change in the refrangibility of luminous rays effected by certain bodies, which, receiving more refrangible rays, emit them again with reduced refrangibility, or, in other words, with a slower rate of vibration.

Now, it is stated by Tyndall and others, the action of calorescence, above described, is identical in character with this, though opposite in direction, being an increase of the refrangibility or rate of vibration, and they have therefore described it as a negative fluorescence.

This conclusion the author of the above paper combats on various grounds, and maintains that all such developments of luminous rays from non-luminous, are but the direct consequence of rise in temperature. Among the earliest instances of negative fluorescence observed, was the case of fluorspar, especially the variety known as chlorophane, which, when placed in a dark oven or otherwise heated below the ordinary point of ignition, becomes luminous.

A great number of experiments made and recorded by Professor Bohn seem, however, to show that this luminosity is the result simply of a slow combustion, inaugurated at a certain temperature, and continuing until the material supplying it is exhausted, this material recollecting, however, after a sufficient period of repose. These experiments likewise prove that insolation or exposure to sunlight is not, as heretofore supposed, essential to this recovery of luminous properties.

The account of experiments and deductions therefrom, in the paper under consideration, is very long, and would need much space even for an abstract; we must therefore content ourselves with remarking, that the proposition stated at the outset is very fully maintained, and that it is pretty clearly proved that no known phenomenon can lay just claim to the title of "negative fluorescence" as above defined.

Heat produced by motion "in vacuo."—We notice in the *Proceedings of the Royal Society* for December, 1866, the continuation of an article from the June number for 1865, on the heating of a disk

by rapid rotation in a vacuum, by Balfour Stewart, M.A., F.R.S., and P. G. Tait, M.A.

The apparatus, as described, consists of a disk of aluminium. (This metal was chosen for its lightness, in order to diminish the weight upon the bearings as much as possible.) The disk was insulated from the bearings by a stud of ebonite, and the shaft revolved in mercury. All heat from friction was thus arrested. The disk of aluminium employed had a diameter of thirteen inches and was one-twentieth of an inch thick, and weighed ten ounces. The deflection of the galvanometer needle, produced by heating the pile, was recorded by means of a small mirror attached to the needle, which, as it moved, caused the reflected image of a line of light to travel over a graduated scale. This arrangement can be made so sensitive that if the temperature of the disk were to rise 1° Fahr., the change would be indicated by the line of light passing over fifty divisions of the scale.

Various experiments were tried, which proved very conclusively that the heating was not due to radiation of heated air. The rise in temperature was the same in a vacuum of hydrogen, or of coal gas, although there is no question that the absorptive, and therefore the radiative power of coal gas, is much greater than that of air.

Other experiments were made with a disk of ebonite, the results showing that the heating of the disk was not caused by revolution under the earth's magnetic force.

Another experiment was tried, to prove whether the heating effect observed in rotation might not be due to heat conducted from the bearings through the ebonite washer. The aluminium disk, separated from its metallic spindle by the ebonite washer, and in every respect the same as when made to rotate, had its spindle artificially heated by a mercury bath to 40° Fahr. above the previous temperature. After the lapse of two minutes the effect upon the pile was hardly perceptible—not more than five small divisions of the scale. It would appear from this experiment that the heating effect observed in rotation cannot be due to heat conducted from the bearings, since a temperature difference between the bearings and the disk, ten times greater than that produced by rotation, causes a heating effect at least six times less than that caused by rotation in a somewhat less time.

Again, from various experiments it would appear that the heating effect cannot be due to vibration of the disk.

It was also shown that the heating effect is independent both of the density and chemical composition of the residual air and vapor around the

disk. The authors of these delicate and systematically conducted experiments, of which we have given the results in brief, conclude their remarks with the following words: "In absence of definite knowledge of the nature of that medium which transmits radiant light and heat, it might be supposed possible that, when a radiant body is in rapid motion, the intensity of its radiation is somewhat increased. But if we bear in mind, that in these experiments the effect was observed after bringing the disk to rest, and that the temporary effect during rotation, sometimes observed, can probably be otherwise accounted for, we are forced to conclude, that, as far as we may judge from these experiments, (and they are of a very delicate nature,) there is no perceptible effect of motion upon radiation."

Editorial Correspondence.

RAILROAD REFORM.

NEW YORK, *October*, 1867.

IT will be remembered that, during a recent session of Congress, certain bills were brought up with a view to a remodeling of the railroad system of the country, and principally directed towards the establishment of "cheap freight lines," under Congressional legislation. The first effort to give force and public approval to this movement was made a few evenings since, through a meeting held in the hall of the Cooper Union Building. The call for the meeting was signed by numbers of our most prominent men; but, among all their names, not a single experienced and noted railway man would have been recognized. There was the philanthropic and large-hearted Peter Cooper, the poet Bryant of the *Evening Post*, energetic, hard-working Jackson Schultz, President of the Health Board, Theodore Tilton of the *Independent*, Henry J. Raymond of the *Times*. I must not omit the ubiquitous, scolding, talkative, but well-meaning "H. G." of the *Tribune*, always on hand for any enterprise affecting the public good, in mentioning a few of the notables assembled on the occasion.

Perhaps no question is so pertinent to the times as this one of "Railway Reform." All know it, and all feel it; but how to begin it, to follow it and carry it out, involve questions so momentous, so intricate and multitudinous, and so affecting the productive energies of the

country, that it requires the wisest and most experienced in railway matters to guide it. Railway economy is a study, a science, as much so as any of the learned professions or true statesmanship. A *thorough* railway economist must not only be familiar with the laws of trade and commerce, but also with the details of operation, the construction and maintenance of way. In this, more than in any other profession, greater cosmopolitan information, so to speak, is required—a more varied acquaintance with almost all subjects, general and scientific. Such men are rarely secured by those most interested, partly from their scarcity and partly from an utter ignorance of what is needed. A man may be a very good grocer or merchant, or a steamship manager, and, indeed, be wonderfully successful in any of these several pursuits; but do they fit him for the responsible position of a railway president or manager? Because a man shows a genius for buying and selling pork, or anything else, does it argue that he is conversant with the manifold requirements of railway management? That seems to be very much the ground of recommendation for many of the heads of our most important railways. There are some exceptions, I am happy to say, to this general rule; but they, by comparison, only serve to make the above remarks more prominent. If only the stockholders themselves were the sufferers, and those whose money was invested in the enterprise, there would be nothing to say, no matter what ignoramus they chose to put at the head of affairs. But it is not so. It is the great public who suffer, and they are made to bleed at every pore. Fettered by ignorance, many of our lines are more of a curse to the trade they affect to foster and encourage, than a blessing. The truth is, that railways must be looked upon more as great public trusts than as private enterprises for gain, and when the two are blended together we shall have real reform, and not until then.

When one reflects upon this necessity to national development, and looks upon railroads as the great civilizers of the age, he is surprised at the great lack of this recognition on the part of the national government. Theoretically, this is not true, but practically it is; for the government allows whole communities to suffer from incompetent working—from monstrous monopolies and avaricious speculators. Every man that travels on a railway or sends an ounce of freight over it, is directly interested in its success and accommodation to him, and should be protected accordingly. Why is it that English and Continental railways are so much better managed than our own, in working, in accommodation to the public, and in fact everything that appertains to

a railway? Take Colburn and Holley's *European and American Railway Practice*, and compare the accurately compiled statistics therein. Our American roads pale in the comparison. To us their economy of operation seems marvelous, especially when we come to compare the cost of keeping up or the "maintenance of way." The dead load hauled to the passenger, or pounds of freight, the saving of fuel and all appointments, are items for a thoughtful comparison. In addition to the economy, the people are protected by government enactment, and are masters and not slaves, at the mercy of ignorant presidents and greedy stockholders.

Every point mentioned above bears directly on the railway reform needed in this country, and "cheap freight" as well as "cheap passenger" lines, with all necessary accommodation, too, would speedily follow. We never can have cheap lines until we have economically operated ones, nor productive lines until we have accommodating ones. It is amusing to reflect upon the "economy" put in practice by the majority of American lines,—the economy that spends the shilling to save the sixpence,—the economy that hems itself in and drives away, instead of enticing and seeking popular sympathy and support,—an economy that provides to-day so that it will last to-morrow, and thus repeated to the end.

Many lines carry freights now that do not pay, and this is true of nearly all through freights—the deficit to be made up by grinding down upon what is called local traffic, where competition does not enter. It is foolish to talk about new "cheap freight lines"—trunk lines from the Atlantic coast to the great West, no matter how well it sounds,—nor will any of the well-meaning gentlemen who took part in the proceedings at the "Cooper Union" be able to call them into being. Mr. Greeley's speech was very pretty to listen to, but this perching the American eagle on the Rocky Mountains, and gratifying the vision with great trunk lines, uniting the Sierras with the Alleghanies, carrying "cheap freight," is a little too soon; and, although it perhaps *is* humiliating to come down to realities from such a high perch, where the expansive view develops expansive ideas, we must begin with what we have, remodel and improve, before cheap, rapid and accommodating railways will be an institution in this country. Listen to the following extract from Mr. Greeley's "speech." Comparing railroads and canals, he says: "Upon the canals you may have the boats not a musket-shot apart, and so steadily unloading one hundred tons every few minutes. Now, this is what we hope to achieve by means of the cheap freight roads.

By the system suggested, there will be no turning out for passenger cars—no waiting upon the track—no leaving a load of cattle or swine waiting for twenty-four hours or more because an express train is behind time. We can have one continuous procession of cars from the Mississippi right to New York, and so unloading, every half hour, a full train of grain or meat, or wool—in fact, everything that the West can supply," &c., &c. A fine picture, truly, this procession of cars and unloading trains every half hour; but with all our mismanagement, the waiting of *twenty-four hours or more* for an express train to pass, when every line has its telegraph, is rather severe—a shade darker than our grocer, steamship president's management, and ought to be painted. It may be of interest to append a condensed plan of these proposed "cheap freight lines." They shall be opened to competition for all who desire to put trains thereon, for which the parties shall pay certain tolls; a moderate and uniform speed shall at all times be maintained; individuals, states or corporations may become stockholders by paying one hundred dollars per share. The company to have no authority to mortgage its road or franchise; no debt contracted without means to pay for it, and the directors to be liable personally if money must be borrowed. This, then, is to be the railroad paradise! It is well the question is agitated, no matter by whom or in what shape it is done; for it is only by continually hammering at the same theme that the people themselves will take hold. A man readily listens and acts in matters individually his own; but when the interests of a community are involved, and matters of public importance need attention, even though affecting him personally, he will bear a great deal before he acts.

At the next meeting of railway reformers we would urge them to take hold of the railroads that we have, and devise some scheme for governmental supervision over them. Let that supervision be of such a nature as to compel all lines to have competent heads, selected for *no other reason* than for capacity and fitness. A railway economist as president would soon have proper men at the heads of the subordinate departments, and who would not see in a good conductor a special fitness for a superintendency. There have been some able men risen from conductorship, but they are exceptional. With such a proper directing brain, our roads would soon flourish under a true economy; half built and half kept up lines would be gradually rendered as permanent as time and material would allow. The fearfully expensive repair-gangs, that eat up the receipts of railroads, would

be no longer needed. A perfect road would diminish the size of machine and repair shops, thus cutting down one of the most serious expenses that a road has to contend with.

With expenses thus reduced to a minimum, freight could be made remunerative at low rates, passengers would be carried more cheaply, and stockholders gladdened with larger dividends. With a government supervision, all lines would operate harmoniously together, and form, practically, one vast organization, from the Atlantic to the Pacific, and from the Canadas to the Gulf. As demands for increased accommodation arise, lines could be doubled, tripled or quadrupled, it may be, carrying Mr. Greeley's half-hourly trains in a "ceaseless procession," with a regularity and cheapness that ought to satisfy him and his conferrees.

Again, assuming New York as the objective point, towards which everything West was straining, as was the assumption of the gentlemen at the reform meeting, they want *new* independent lines built. Did it, I wonder, ever occur to them that, with rare exceptions, the most desirable localities for Western lines was already occupied? Hardly any of these lines approach their capacity as carriers, if properly worked. What folly, to talk about new railways, when we are amply supplied with existing ones. As a rule, carrying capacity is always in excess of productions to be carried, and always will be; for the carrier, of whatever nature, invites the producer entirely through facilities of transportation, which introduce the elements of time and cost. Not a railroad in this country is pressed to its utmost capacity, if *properly* managed.

It is not new roads that are wanted now, but a development of the old,—make them units of a vast whole by the supervision of the National Government, and put at the head of these separate units men who are thoroughly educated railway men. A. P. B.

ERRATA IN LAST LETTER.

Page 226, 6th line from bottom, for *chain* read chair.
" 227, 1st line from top, for *turned* read pierced.
" 227, 10th line from top, for *Wood* read road.
" 227, 10th line from top, for *Harlam* read Harlem.
" 227, 3d line from bottom, for 10 *inches* read 2 inches.
" 228, 19th line from top, for *certainly* read entirely.
" 228, 13th line from bottom, for *ranging* read varying.
" 229, 11th line from bottom, for *filled up* read constructed.

Civil and Mechanical Engineering.

(Continued from page 251.)

THE EAST RIVER BRIDGE.

ALTHOUGH the cost of this masonry will be about $600,000, I feel satisfied that, if my suggestions are carried out, the eventual rent of safes will pay more than ten per cent. upon the above cost; for these vaults once established and placed under good management, would soon be filled with three-fourths of all the investments and securities now held in this country. No rock will be found available for anchoring the suspension cables on either side of the river. Each of the four cables enter the anchor-walls at an elevation of nearly 80 feet above tide, and passes through the masonry a distance of 20 feet, at which point a connection is formed with the anchor-chains. These are composed of ten sinks; the first one is 18 feet long, the others are 12 feet 5 inches long each, measured from centre to centre of eye. Each chain has a total length of 120 feet 9 inches, and forms a curve of one-quarter of a circle, or exactly 90 degrees. The first link which connects with the cable occupies a horizontal position, while the last one is placed in a vertical line, and is attached to a massive anchor-plate, which supports the superincumbent masonry, whose weight must be great enough to balance the greatest tension to which the chain can ever be exposed. By this curvature of the chain a portion of its tension is conveyed into pressure, directed upon the wall. This pressure will be supported at each knuckle by cast iron plates, which are to be bedded upon large blocks of granite.

The greatest weight which the cables and stays will ever have to support was stated at	4,753 tons.
Allowing six times, we get 4753 16	20,538 "
Deduct supporting power of stays	15,000 "
Leaves for the cables to support	13,538 tons.
The tension resulting from this weight is 13,538 × 1·64	22,252 "
Tension of one cable	5,550 "

And this will be the tension each chain will have to support. Now,

estimating the ultimate strength of good steel bars at 50 tons per square inch, the section of each chain will be

5550 divided by 50		111	square inches.
Allowing 40 tons		139	" "
" 30 tons for wrought iron		185	" "
" 25 " "		222	" "

Whether steel or iron bars should be employed, and of what qualities, will be decided by their relative strength and relative cost. We want the greatest amount of strength for the least amount of money, let it be iron or steel, home-made or manufactured abroad. The approach on the New York side from Chatham Street to the anchor-wall will be 1336 feet long. On the Brooklyn side this distance will measure 836 feet. All this ground is valuable, and should not be sacrificed, but, on the contrary, utilized. Most of the railroads which pass over the city of London are supported by brick arches, and the ground thus occupied is, to a great extent, rendered valueless. My plan contemplates no sacrifice of the kind, but, on the contrary, involves, on the New York side at least, a decided improvement of all the blocks which will be passed over west of the anchorage. If authority can be had, I would propose to open out a new street from Chatham or William to Cliff Street, or to Franklin Square, running alongside of the bridge on the north side of it. This Bridge Street, as it might be properly named, would present two new fronts. The south front would be formed by the buildings underneath the bridge. The iron girders which support the floor will rest upon small pillars of cutstone or brick masonry, which will, at the same time, form parts of the inclosing walls. The intermediate supports may be built up in the same way; but a better plan will be to put up iron columns in connection with the different iron floors and division walls. An inspection of the plan shows how the bridge front of the new street may be made very imposing and attractive in its architectural features, and how all the ground can be utilized. It is desirable that the construction of the bridge, and of the improvements underneath, should be carried on simultaneously and upon one and the same plan. The bridge-floor will thus form the roof of the houses underneath, and must be made fire and water-proof. My estimate includes the necessary pillars for the support of the bridge-floor, but no more. The balance of the work must be charged to the improvements of the ground, which will pay for themselves. For this same reason have I not included an estimate of real estate, because its value will not be destroyed, but, on the con-

trary, it will, in connection with the contemplated improvements, considerably be enhanced. In connection with this subject, I would further suggest that one or more blocks between William and Rose, or between Rose and Vandewater and Cliff, might be built up to serve as market halls. A good market, conveniently located, will be wanted sooner or later in this part of the city, either to supersede the old Fulton Market, or to better serve a vast and dense population all around, within a radius of half a mile. This hall would be most convenient for all the marketing which will come over the bridge from the Brooklyn side. And since the elevation of the bridge-floor above the ground is more than is needed for a market hall, one or two floors may be utilized above. The above remarks will also apply to the Brooklyn approach, but only to a limited extent. A part of James Street, next to the anchorage, might be appropriated for a market hall. One portion of the same street, higher up, will have to serve as an engine-room to work the wire rope for the propulsion of the cars. The results of the boring near the Brooklyn tower are so far favorable to a good foundation. Whether the timber platform may be allowed to rest on the bed of the excavation, or whether a pile foundation will become necessary for its support, this question cannot and should not be decided now. If all the timber is contracted for during this fall, so that it can be got out during the next winter and delivered next season, I entertain little doubt that the Brooklyn foundation may be successfully completed during the course of next year. No boring has been attempted yet on the New York shore. The boring on the Brooklyn side will be stopped at a depth of 100 to 150 feet, or as soon as rock has been reached. The machinery will then be transferred to near Pier No. 29, New York side, and a bore-hole commenced. There a greater depth of water will at once be encountered. The timber foundations will be formed by layers of flat timber alternately crossing each other, laid with wide open joints, and these will be filled with concrete. An impregnation of the timber with cement not only has the effect of hardening it, but it will also afford some protection against the sea-worm. This protection, however, will be rendered more effective and complete by covering the outside of the timber with a heavy layer of concrete, and this again will be protected by a heavy stone filling intermixed with gravel and sand. In this manner the whole timber foundation will be hermetically enclosed by a heavy body of concrete, and this again protected against the wash of the sea on the river front. It is known that the sea-worm, which bores into the

wood, does not penetrate mineral substances and stones, and we are also certain that a well-manufactured concrete, if left undisturbed, will soon become as solid as rock, and will therefore effectually keep out those dangerous mollusks. In another half-century Liverpool and London, as commercial centres, will rank second to N ew York. This is no futile speculation, but the natural and legitimate result of natural causes. As the great flow of civilization has ever been from the East toward the West, with the same certainty will the greatest commercial emporium be located on this continent, which links the East to the West, and whose mission it is in the history of mankind to blend the most ancient civilization with the most modern. The old and the new are to meet on this continent, and this will be effected through the means of commerce. About 4,000,000 tons of shipping now belong to the port of Liverpool. About 5,000,000 tons enter the port of London. In 1866 over 2,500,000 were cleared in New York for foreign ports, and about the same tonnage from foreign ports entered during the same year. This tonnage, in 1864, amounted only to 1,500,000 tons. The population of the city of New York, proper, according to the United States census, was, in

1810.....	60,000	1825.....	166,000	1840.....	312,000	1855.....	670,000
1815.....	96,000	1830.....	262,000	1845.....	371,000	1860.....	814,000
1820.....	123,000	1835.....	270,000	1850.....	515,000		

This shows an average increase of over 50 per cent. in every decade. Accordingly, we may estimate the population in 1870 at 1,300,000, and in 1880 at 1,950,000.

The population of Brooklyn was, in

1810.....	4400	1839.....	15,400	1850.....	97,209	1865.....	350,000
1820.....	7200	1840.....	36,210	1860.....	267,000		

This table shows that the population of this city has more than doubled every ten years. I may therefore assume, without overestimating, that its population will be in 1870, 534,000, and in 1880, 1,068,000.

According to the official statement of the Union Ferry Company, they are now transporting 40,000,000 of people annually across the East River. The aggregate travel by horse-railroad cars, in the city of New York, is estimated at over 100,000,000 of persons annually. With these figures before me, am I wrong in estimating the travel across the East River at 80,000,000 of people annually ten years hence? A census in 1870 will not exhibit a population of less than 2,000,000

in New York and adjoining cities, including Newark and all within a radius of ten to twelve miles. All this population may be considered as belonging to New York, because their business is in New York. And I am persuaded that a large proportion of this human hive would prefer to live in Brooklyn and environs, provided they could enjoy speedier means of conveyance than they now have. The proposed bridge over the East River will cost from $6,000,000 to $7,000,000. My estimate sums up $6,675,357. The question now is, Will the future intercourse between the two cities justify such an outlay? And the proper answer to the question is, That the future growth of Brooklyn will keep even steps—no faster, no slower—with the additional facilities of travel which will be created. If the proposed bridge shall possess capacity of 40,000,000 annually, these 40,000,000 will be there as sure as the bridge is built. And if the bridge is not built, there will be so much travel less, because without additional facilities no additional travel and intercourse can be expected. These 40,000,000 are no myths, only to be found on paper. But when the bridge is completed they will make their appearance in due time, because they will simply form a portion of that natural and legitimate increase of the population of the whole county, which will have centered about New York, in order to carry on the commerce of the world. This general increase of population is sure to take place, in the whole county, as well as about the city of New York, *bridge or no bridge*. It remains for the people of Brooklyn to decide whether they will attract their legitimate portion of this additional increase or not. The new and improved facilities which will be offered by the bridge will create a travel of its own, totally distinct from, and independent of, the ferry travel. The existing ferries will continue to do as much business after the completion of the bridge as they are doing now. That large travel which will be confined to the river shore will forever continue to use the ferries. But the still larger travel away from the shores, and the up-town travel, will hereafter go by the bridge or not pass over the river at all. Its erection will simply provide for the future increase of travel, and will therefore prevent an overcrowding of the existing ferries, and will render unnecessary additional ferry routes and ferry boats. Of the same width as Broadway, the bridge will form a great avenue between the two cities, and will afford a communication so superior and so speedy that the idea of competition can never be entertained. While the bridge will be certain of an overwhelming patronage, in consequence of its superior

access and facilities at all seasons and at all hours of the day and night, the ferries, on the other hand, will, by virtue of their location, continue to do a full business. While the ferries will forever retain a monopoly of the river shores, the bridge will command all the vast travel *between* the shores. The time will arrive when substantial tunnels will be constructed, at an immense cost, *under* the bed of the river, for the express purpose of transporting freight. To sink iron tubes, as has been proposed, would turn out a very temporary shift, because they would surely be destroyed in a very few years by the united action of tides and of rust. Permanent tunnels of masonry are practicable, and can be made at a heavy cost. It will be done in course of time, when money is worth 2½ per cent., and the population shall have increased ten-fold. To the American business man, time is money. He will not hesitate to pay a charge of five cents for one mile of steam travel, when he can traverse this distance, from the centre of one city to the centre of the other, inside of five minutes, and when he is also sure that this conveyance is always at his command, day and night, and that he may ride in comfortable cars, protected against the inclemency of the weather. Suppose, now, that 40,000,000 passengers should be transported annually in the railway cars at a charge of one cent per head; this would amount to 40,000,000 cents, or $400,000; at two cents, $800,000; at three cents, $1,200,000; at four cents, $1,600,000; at five cents, $2,000,000.

Now, these receipts may be considered net receipts, because the revenues from the two roadways and from the central promenade are not included. I am fully satisfied that this last item alone will be very heavy, because every stranger in the city will visit this promenade, and will enjoy its pleasures and its sights. The annual expenses of the bridge will be very light, and will only be a fraction of the receipts from the central promenade alone. The receipts from all sources will be so immense that the Bridge Company, in a few years after the completion of the work, will feel justified to put up great magnificent depots and portals at both termini, which shall be a credit to the two cities. A revenue of $2,000,000 will pay ten per cent. upon a capital of twenty millions, and fifteen per cent. upon an investment of thirteen and a half millions. But the work will only cost from six to seven millions, and the investment in real estate will pay good returns of their own.

In speaking of the cost of the work, it is proper to remark here that the present prices of materials and the rates of wages rule high,

and that if a change takes place it is reasonable to expect that this change will be downward and not upward.

For the special consideration of the property holders and tax payers of the city of Brooklyn, one more observation should be made. The taxable property of this city in 1864 was $119,000,000. In 1865 it increased to $123,000,000, which increase is at the rate of three and a half per cent. Now, it is plain, that as the population of the city increases, so will its taxable property. And it is also certain that this increase will be brought about by the building of the bridge in a faster ratio than by any other means. Assuming, at a low estimate, a ratio of increase five and a third per cent. in place of three and a third per cent. after the completion of the bridge, the additional increase of valuation of two per cent. would amount to from $2,000,000 to $3,000,000 annually, and would pay for the whole cost of the work in less than three years.

(Continued from page 241.)

THE NEW YORK "CENTRAL PARK."

By WILLIAM H. GRANT, Superintending Engineer.

CHAPTER V.

SUPERSTRUCTURE OF ROADS CONTINUED—GRAVEL ROADS WITH RUBBLE FOUNDATIONS—ROAD-GUTTERS.

Description of gravel roads on rubble bottoms. Difficulties of construction in regard to drainage. Care required in maintenance and repairs. Ultimate economy in favor of paved bottoms for roads subjected to severe service. Methods of screening gravel. Curb and flag-stone gutters. A less expensive rustic gutter, similar in form. Brick gutters not specially desirable. Cobble-stone gutters with blue-stone curb. Quarry stone gutter without curb; this form generally adopted. Preparation of gutter-stone and method of construction. Advantages of gutters with raised curbs.

Gravel Roads with Rubble Foundations.

THE gravel road of this form of construction was made, so far as relates to the treatment of the gravel, in the same general manner as the foregoing road, except that no portion of the gravel was screened. The gravel was applied above the rubble foundation in about two equal

layers, making a full thickness, when rolled down, of five inches. The first layer was rolled with the light rollers, and the next layer was added and rolled with the heavy roller.

The gravel was used in the state in which it came from the bank. The surface of the top layer was evenly adjusted and coated, before rolling, with binding material, as in the case of the former road, and about the same quantity and quality of binding material were used.

In consequence of the gravel being in its natural state, containing fine gravel and sand, it required somewhat less rolling to compact it than when screened. All the attention in the way of watering, raking and adjusting was given to it, to produce a true and firm surface, as in the case of the screened gravel road with paved foundation.

The rubble foundation, [Plate I., Figs. 4 and 5, facing page 238, Vol. lii.,] which is the distinguishing feature of this kind of road, was constructed in the following manner:

The stones were selected from the rock excavations of the Park, ranging in sizes from about 12 inches the longest way, down to such as were not over one-third that size. The stones were, of course, angular and of all irregular shapes, such only as were very thin (or very unsound) being excluded. It was the aim, however, to procure them of as nearly an uniform size as practicable.

It was not considered necessary that the stones should be as sound or as hard as for a Telford pavement; rotten or shelly or partially decomposed stones were not admitted, but their quality beyond this was not regarded as of special importance.

The rock excavations, by the ordinary mode of blasting and quarrying, furnished but a small portion of the stone of the necessary size, and the balance was obtained by sledging up the larger blocks in the same manner as had been done for the Telford paving stones. The hardest and most difficult stones to break were passed by to save unnecessary expense.

When the stones were deposited on the road-bed—the latter having been prepared as heretofore described—such as were found to exceed very materially in size the dimensions desired, were again broken as they were met with by the men who were employed in attending to the delivery and the spreading of the stones.

The layer was formed from 10 to 12 inches deep, and the surface was adjusted by packing the smaller stones in the interstices and going over with a hammer, and breaking off protruding points, and more or less breaking up and reducing the prominent top stones.

After this the layer was "surfaced" by spreading over it such finer rubble or quarry chips or scrapings and refuse from the stone quarries, as were available, to fill and smooth over all interstices. To this latter material was added a small amount of binding material, such as was made use of for compacting the gravel, and the whole having been properly moistened by sprinkling carts, was next firmly rolled.

The processes of surfacing and rolling were thorough, as it is important to effectually close all apertures and interstices of the surface of the rubble to prevent the gravel from working down into it. It is also essential that this should be done in such a way as to prevent, as far as possible, the filling up of the lower cavities of the rubble layer, so that its cellular character may remain unimpaired to facilitate drainage and prevent, in the greatest degree, the action of frost.

The security of such a foundation depends upon the effective manner in which this latter work is done. The tendency of the rubble stones is to work upwards, in consequence of the jar and vibration caused by the travel over them, the overlying gravel working down and insinuating its pebbles into the crevices and underneath the stones and aiding the operation, it being the natural result for the finer material, under such circumstances, to work to the bottom, and the coarser to come to the top.

This is a well-understood difficulty with road-makers in making roads of this character, and from the very common failures that have attended the effort it has been regarded as nearly insuperable. It would doubtless be *less practicable* to overcome the difficulty in roads that are subjected to heavy and promiscuous traffic, than in such as are here described, for the reason that it would be necessary to use so large an amount of surfacing material over the rubble stones for security, as to injuriously affect some of the important conditions of the work. In the case of the roads under consideration, this has been found to be an impediment to the fullest success that was desirable. The surfacing of the rubble stones in the thorough manner that was considered necessary, has the effect to check, in some degree, the drainage of the gravel above. The differences in this respect between the roads with rubble bottoms and those with paved bottoms is discernible in wet weather. As all practicable facilities for free drainage are held to be important, not only on account of the immediate effect of water in softening the materials and subjecting them to increased wear, but as to the effect of frost also, it would be desirable to avoid this difficulty. No way can be seen, however, to do so without incurring a greater diffi-

culty, and it seems that it must be viewed as a compromise, rendered necessary for the sake of the direct economy of using rubble stones for a road foundation without incurring the expense of putting them in the form of a pavement.

No tendency has been observed, in the roads of this kind, of the stones to work upward or to become loosened or displaced, the attention given to the packing of the stones and to the surfacing and rolling of the layer, the travel and the working of teams upon it, together with the subsequent rolling of the gravel above, have proved entirely effective upon this point. No fears are entertained that any difficulty will hereafter ensue, so long as the original depth of the covering of gravel is kept good, and no serious obstruction is permitted to occur to the surface and subdrainage of the roads.

Much depends upon the protection given by the superincumbent gravel to the rubble bottom. The gravel must never be permitted to become much reduced by wear before renewal; it is also necessary that it should be kept in a firm, compact condition. Whenever it becomes softened by rains or loosened by the going out of the frost, it should be followed by immediate rolling. This is quite as essential for the proper condition of the road for *use* as for the *security of the foundation*.

With these precautions—all the care that has been mentioned having been bestowed upon the first construction—there is no reason to doubt that roads of this kind can be made to render very fair service as park roads. Where economy in the first expenditure is a controlling necessity, they may be resorted to as coming the nearest to gravel road with paved foundation of any practicable form of construction. They require more care and watchfulness in use than the latter kind of road, and cannot be regarded, under all circumstances and conditions (except as to cost), as quite so desirable. They are well adapted to ordinary private roads that are exposed to light service and moderate wear, and for such use they can be very confidently recommended.

Taking a broad view, however, of the question as to their utility and adaptability to a public park, where almost ceaseless service may be required of them, and a service which, although apparently of a light description, is really severe, and considering the peculiar contingencies that this kind of road is liable to, such as a possible oversight or neglect in the renewal of the gravel, repairs and attention to drainage, it cannot be said that the single advantage of cheapness

of construction outweighs the safer and superior qualities of the more costly form of road.

It would not, in fact, be a matter of surprise if, under these circumstances, the gravel roads of the Central Park, with paved bottoms, should prove superior to those with rubble bottoms as to ultimate economy.

Methods of Screening Gravel.

The following method was adopted in screening gravel for the Park roads:

Two screens were placed in a strong frame-work, the one above the other, in inclined positions. The frame was constructed with a platform, so that wagons could drive on it and discharge the gravel into a hopper over the screens. The meshes of the upper screen were adapted to the stopping and turning aside of stones that were above the prescribed size. The meshes of the lower screen were adapted to stopping all the intermediate sizes down to the lowest that were desired for use on the roads, the finer portions of the gravel, together with sand and dirt, passing freely through the screen to the ground. The screens were set in a frame in such a way that they could be shaken, when necessary, by a hand-lever to facilitate the operation. The stones were discharged on one side by themselves, and were removed and used in making gutters for the walks. The gravel intended for the roads was discharged on the other side, and was removed and hauled away as it accumulated.

The finer gravel and sand—there being but little dirt in it—was used in making walks, and was very much improved for that purpose by the screening.

The apparatus was simple and easy of construction, and worked very well. The saving of expense over the ordinary mode of hand-screening, *i.e.* by casting up the gravel with a shovel on a single screen, was about 75 per cent.

A still better mode than this would be recommended where practicable, that of screening the gravel at the bank or locality where it is obtained. The work could, in most cases, be done in this way to better advantage, especially if the large stones and the finer gravel and sand were not wanted, (as they happened to be on the Park,) as the transportation of so much material from the gravel bank to the work would be saved.

If gravel is delivered by a vessel at a wharf, a similar plan to that

first mentioned could be employed, for either single or double screening, the gravel being hoisted out of the vessel by horse-power (in the manner that coal is unloaded), and dumped over the screens. It might be practicable, in such a case, to so arrange the apparatus that the gravel would discharge from the screens directly into wagons or carts, and thus save the labor of again shoveling it up.

Wherever gravel is to be used in large quantities, these expedients will be found greatly conducive to economy.

(To be continued.)

THE MONT CENIS SUMMIT RAILWAY.

FROM the Glasgow *Daily Herald* (forwarded to us through the kindness of Mr. Henry Cartwright) we extract the following interesting account:

"We have already apprised our readers of the passage of the first train across this remarkable line of railway, by means of which the system of French railways, terminating at St. Michel, in Savoy, connect with the railways which commence at Susa, at the southern or Italian foot of the Pass, and which now connect together, and extend either directly or circuitously to all the leading places and cities of Italy. The length of this railway system is at present 3040 miles, and there is every prospect of about 250 miles being opened for traffic in the course of this or next year. The *Observer* has an interesting account of the opening trip, and of the line itself, which is one of European interest, shortening, as it does, the distance between London and a number of the places of continental note, and also with the East. The Mont Cenis Railway Company (limited) is the name of the undertaking. This company, the President of which is the Duke of Somerset, the Chairman Sir James Hudson, K. C. B., and includes amongst its Directors the Duke De Volambrosa, Lord Arbinger, Mr. Brassey, Mr. Fell, Mr. Broghen and other gentlemen, was launched in the early part of last year. Its purpose was to construct a railway upon a portion of the road-bed of the Mont Cenis Pass, the total length of which is 49 English miles, under the terms of a concession granted by both the French and Italian governments to Messrs. Fell and Brassey. The concessions stipulated, among other conditions, that the gauge of the railway should be only 2 feet 7½ inches, in lieu of the gauge that prevails all over the continent as well as in England, with

the exception of portions of the Great Western, namely, 4 feet 8½ inches; that at all steep gradients there should be a centre rail in accordance with the system of Mr. John B. Fell, and that the width of the carriage way left for road traffic should not be less than 16 feet. The two severest railway ascents in the world are at the Soemrring Pass of the Alps, the average gradient of which is 1 in 47, or 112 feet in the mile, and at the Giova incline over the Apennines, near Genoa, 1 in 40, or 131 feet in the mile. The engines at both places are 55 tons weight, and of very large evaporating power, yet they cannot convey loads half the weight that engines with similar evaporating power are in the habit of conveying on railroads with good gradients. For the purpose of increasing adhesion without increasing weight of engine, Mr. Fell has invented and patented the centre rail system—that is, he introduces parallel with, and exactly in the centre between, the two ordinary rails a centre rail, which is raised 9 inches above the surface of the two ordinary rails; and in order to obtain adhesion to the centre rail, the engine has, in addition to the ordinary perpendicular wheels, such as all engines have, four horizontal wheels, two on each side of the engine, which are made to rotate along the sides of centre rail by identically the same steam from the cylinder that operates upon the perpendicular wheels. The effect of this rotation of the horizontal wheels upon the sides of the centre rail is to increase its adhesion. The amount of this increased adhesion was proved by Captain Tyler last year. An engine ascended an incline of 1 in 12, equal to 400 in the mile, with the steam acting only upon the horizontal wheels. The weight drawn was seven tons. With steam applied to both the perpendicular and the horizontal, the weight drawn was twenty-four tons. In this fact is contained the whole secret of the extraordinary development and marvelous increase of power obtained by the introduction of the centre rail combined with the action of the horizontal wheels upon it. Yet, simple as the fact is, now that it is known and appreciated, an interval of nearly five years has elapsed between the time that such increased power first struck Mr. Fell, and the time of his bringing it into complete and successful operation. So far as regards gradients; and we must now say a few words with respect to curves. On ordinary railway curves, except in the immediate vicinity of stations, are never of less radius than 400 to 500 yards, and even with such it would not be safe to run trains over them at high speed. The sharpest, in order not to slacken the pace of the engine, should not be less than 700 yards. Mr. Fell, however, has no curve on the Mont Cenis Railway of greater radius

than 40 metres, a little less than 44 yards, and it is a remarkable circumstance that the engines and trains go round them without the slightest apparent difficulty or additional strain, and with a total absence of that grinding which is invariably heard by passengers in an ordinary train going round curves. This fact was very clearly developed in the trial-trip of Monday last. The British Post Office, being desirous of availing itself at the earliest possible period that it can do so with safety and certainty of the Brindisi route for the transit of the eastern mails, deputed Captain Tyler, R. E., to make an inspection of the railway. He accordingly proceeded the week before last, for the third time, to Mont Cenis. He was accompanied in his visit by Captain Beasmont, R. E., the Duke de Valambrosa, Mr. Bragden, Mr. Fell, Mr. Brunlees, C. E., Mr. Thos. Morris, a director of the Central Railway Company, and by the principal members of the staff of the Mont Cenis Company. Precisely at half-past six on Monday morning last, the gentlemen just named, accompanied by about forty-five other persons, to whom invitations had been given to be present at the trial-trip, started from St. Michel. The train consisted of engine No. 2, to which were attached two carriages. The passage of the mountain may be divided into two nearly equal parts—that from St. Michel to Lanslebourg, little less than 25 miles, and that from Lanslebourg to Susa, a little more than 24 miles. St. Michel is 2493 feet above the level of the sea. From thence to Lanslebourg the rise is only 1994 English feet, or at the average rate of nearly 80 feet to the mile. There are only two real hills in the whole distance—one with a gradient of 260 feet in the mile in the vicinity of the Modane or French entrance of the great tunnel of the Alps, for a length of a mile and a half, and the other with a gradient of 264 feet in the mile, five miles further on, for a length of about a mile and a quarter. Not the slightest difficulty was experienced by the engine in surmounting these hills, although the road at both of them is not yet fully completed. Nevertheless, it was marvelous to see the ease with which the engine ascended them. At Modane a large number of persons were collected at the top of the incline, and as soon as the train arrived there the people loudly cheered it and its occupants. At Lanslebourg, the most important village on the Pass, with a population of above two thousand, a triumphal arch was erected across the line, and as the train passed under it was greeted with the most vociferous cheers by the whole population, which turned out to a man to do it due honor. Hitherto, from the comparatively easy ascent, the work that the engine had to perform might be considered as child's play;

but at Lanslebourg the real work of climbing commences. From here to the summit, exactly 6½ miles, the ascent is 2214 feet, or at the rate of 350 to the mile, with several curves, the radii of which are only 44 yards. At Lanslebourg, Mr Brunlees took possession of the train, and became not only engine-driver, but director of the signalmen on the train, and of the brakesmen. The train started amid enthusiastic cheers, and also amid the hopes, fears and anxieties of every person connected with the company. But not only was a good start made, but the pace was most gallantly and unflinchingly maintained during every inch of the 6½ miles, notwithstanding an engine had never before traversed the line, and in many parts the ballast sank so much as to materially affect the gradient. The whole distance was traversed in precisely forty-seven minutes, or at the rate of 8 miles an hour. At the summit, which is also the frontier of France and Italy, the train stopped under a triumphal arch, festooned with green leaves and many of the beautiful Alpine flowers, of which there is hereabouts such profusion during the summer season. Here the occupants were entertained with an excellent *dejeuner;* and as soon as ample justice had been done to it, toasts to the honor of their guests were proposed with genuine enthusiasm, and responded to with equal fervor; and as the train resumed its journey a second salute of twenty-one guns was fired, the first having been given just as the engine had passed from French to Italian territory. The train again in motion, proceeded for 3 miles close to the banks of the Cenis Lake, which yields a capital trout six months in the year and is frozen over for the other six; thence to La Grande Croix, nearly five miles from the summit. This is the place at which the descent of the mountain commences. Here it was necessary to see that everything was right as regards the brakes. The brakesmen having received proper instructions (for they had never previously seen or been upon the line), the train started, and it was at once seen that, from the admirable arrangements of the break-power, the train was as completely under subjection as if it had been running upon nearly a level rail. Yet for 6¼ miles to Mollavetta the gradient is 1 in 14, or 376½ feet in the mile, and from Mollavetta to 6½ miles it is not much better, being 1 in 15, or 350 feet in the mile. The most complete control over the engine and train was never lost for a moment, for they glided steadily during the whole descent at the rate of about 8 miles an hour into Susa. At this ancient city a fresh ovation awaited the English party. It will thus be seen that the trial-trip has been completely successful, and that henceforth the Fell system for crossing mountains by railway must be acknowledged as a

great fact. But there is a remarkable circumstance connected with the passage of the Alps by railway, which must not be omitted in this narrative. Precisely eight days previously—that is, on the 18th of August,—the locomotive crossed for the first time another Alpine pass—that of the Brenner; so that in one respect, that of precedence, the Austrian engineers have beaten those of England. On the other hand, however, it has to be remembered that the works on the Mont Cenis Pass were not commenced till four years later than those on the Brenner. However, there is room, and there is traffic in abundance for both lines, as well as hereafter for the two if not for three more railways which are sure to be constructed across the Alps within a comparatively limited period. The Brenner railway opened for general traffic on the 26th of August. The Mont Cenis Railway will, it is expected, commence business on or about the 1st of October."

The use of a centre rail is by no means new. The plan has been applied in this country a great many years ago, as will be seen by reference to some remarks made by Mr. Coleman Sellers at a monthly meeting of this Institute, October 18th, 1865. (See this *Journal*, vol. l., page 253.)

On that occasion Mr. Coleman Sellers, in allusion to a previous statement, remarked as follows:

"The use of two outside rails, and one central adhesion rail, was patented many years ago by Mr. George Escol Sellers. The person to whom Prof. Morton alluded was Mr. Trautwine, the engineer of the Panama Railroad, who advocated the use of this plan across the Isthmus. The engines were so built, but the engineer who succeeded him concluded to cut down the road and use common engines. Since that there was a road proposed in Pennsylvania, and two engines were built for the road in Cincinnati. An engine was run in New York on this plan, weighing 1100 pounds, which was capable of drawing 30 pounds up a grade of 250 feet to the mile with ease. The plan on which they were constructed was better than that at present used in Europe, as they were so constructed that the whole weight of the train should act in producing adhesion, so that the heavier load the harder the grip on the central rail. We have at present in use at our own works a hammer operating upon the same plan, so that the heavier the hammer used the greater will be the bite of the wheels which lift it. I speak of this invention because I think it is due to America to say that it is purely American, and was advocated and used so long ago that the patent has expired; so that you can judge very well that we have precedence of any other country in this case."

Mechanics, Physics and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

PART I.

Containing—

§ I. Definitions and Introduction to the Inductive Method.
§ II. Instruments used in Precise Measurements.
§ III. Methods of Precision.
§ IV. Manners of Expressing a Law.—Law evolved from the numerical results of Observations and Experiments.
§ V. The general Properties of Matter.—The Constitution of Matter according to the Molecular Hypothesis.
§ VI. Capillary Attraction.

§ I. *Definitions and Introduction to the Inductive Method.*

Physical science is the knowledge of the laws (*c*) of the phenomena (*b*) of matter (*a*).

(*a*.) Matter is that which affects the senses. It always presents the three dimensions, or, in other words, occupies space.

It exists throughout all known space as a highly elastic and rare medium called *ether* (proof of this given in optics), and in this medium circulate dense bodies of spheroid forms, separated from each other by distances which are immense when compared with the size of these bodies; such are the planets and asteroids of celestial space, and the earth on which we live.

Aërolites and meteorites are celestial bodies of smaller size, which, at certain periods (November 12th and August 10th) cross the orbit of the earth.

Comets are highly rarified nebulous bodies of various and changing forms, circulating in orbits which are so eccentric, that they are not visible to us in their remote situations; while at other times they are much nearer to the sun than any of the planets. The comet of 1680, when nearest to the sun, was only one-sixth of the sun's diameter from his surface.

The motion of comets retarded by the resistance of the *ether?*

The above is a statement of all known matter, and physical science is that branch of knowledge which considers all the various phenomena which this matter presents.

From the investigations of chemists on terrestrial matter and from the spectroscopic examination of celestial bodies, all matter can be resolved into (at present) sixty-three *elements*.

According to the atomic theory (see § V.) all matter consists of exceedingly minute, absolutely hard and unchangeable *atoms*, separated from each other by distances which are very great when compared with the dimensions of these atoms.

As in interplanetary space exists the rare ether, so interatomic space is occupied by the same elastic medium: (proofs of above given under Undulatory Theory of Light and Heat.) Matter exists in the three states of solids, liquids and gases.

Each organ of our senses is so constructed that it can only take cognizance of those effects which it was specially designated to receive. Thus, through the eye we perceive light, but not sound; and the ear does not take cognizance of light, nor of flavor, nor of odor.

All the senses are modifications of touch.

In touch, taste and smell, the organs of these senses come in contact with the matter that we touch, taste and smell. In the cases of sound, of light and of heat, these effects are propagated through an intervening elastic medium whose particles, vibrating in unison with the particles of the sounding, luminous or heated body, cause the nerves of the ear, of the eye or of the skin to pulsate; and thus we have special sensations which we severally interpret as sound, light and heat.

Experiment showing the transmission of sound—vibrations through the air, through a liquid and through a long rod to the ear. The human body can be the intervening vibrating medium to transmit the sound.

Experiment. Sound not propagated through a vacuum. *Ether* is the intervening vibrating medium in the case of light and heat.

A *shadow* is not matter, because it does *not* affect the senses. The light reflected from the surface, contiguous to the shadow, affects the eye; but from where the shadow is, no effect emanates, and the consciousness of the *absence of an effect* on that part of the eye where the shadow is projected gives us the idea of darkness.

According to Helmholtz and Du Bois Raymond an effect is propagated along the nerves with a velocity of 93 feet in one second.

(*b.*) Phenomena. A collection of associated facts.

Example. Compression of air. Here the associated facts are two (1). The volumes of air corresponding to (2) different pressures. The

fall of a stone, associated facts. (1) Spaces fallen through, and (2) the times occupied in falling through the spaces.

Every physical phenomenon is either motion or the result of motion.

Examples. In the phenomena of astronomy, mechanics, acoustics, light, heat, electricity, chemistry, botany, zoology.

The idea of *motion* necessarily embraces two others, viz: that of *space* and that of *time;* for a motion must take place in space, and must happen with more or less rapidity, whence our idea of time. (See Instruments used to Measure Time, under § II.)

(c.) Law. The expression of the general relation which pervades a class of facts, or the rule according to which a cause acts.

Examples. The law of the compression of gases; volumes of gases are inversely as the pressures to which they are subjected. Gravitation: Gravitating effect is directly as the masses, and inversely as the square of the distance between the gravitating bodies. Sound, light, heat, electric and magnetic attraction diminish in intensity inversely as the squares of the distances from their centres of origin. Reflection and refraction of light.

Universality of these general relations throughout the universe. Importance of these general expressions in assisting the memory. A law embraces in itself all the myriads of facts of which it is the generalization.

The use of a law is shown in its application to the practical purposes of life.

Examples. Application of the law of the compression of gases; of the reflection and refraction of light; of the pressure of steam at different temperatures; of the laws of dynamic electricity.

Without the knowledge of the law of a class of facts, we are obliged to make experiments to solve each individual problem, while, if we had the knowledge of the law, the solution of the problem is a mere deduction from the law to which it belongs. Examples drawn from above laws.

The money-value of a law to the engineer, and to the industrial and commercial world.

The discovery of laws is the object of science.

The logical arrangement of all the known physical laws constitutes physical science.

"*Classification of the Physical Sciences.*

I.	II.
Inorganic.	Organic.
a. Celestial Phenomena.	
1. Astronomy,	1. Botany,
2. Meteorology (part of).	2. Zoology.
b. Terrestrial Phenomena.	
1. Physics,	
2. Chemistry,	
3. Geology including mineralogy."	

Prof. J. Henry.

Physics considers the laws of the general phenomena of matter, or is the study of the laws of those phenomena which do not bring about a permanent change in the constitution of bodies.

Examples. Fall of a stone, compression of gases, expansion of bodies by heat, reflection and refraction of light, &c.

Chemistry considers the peculiar or individual phenomena of bodies, or is that science which studies those phenomena which bring about a permanent change in the nature of bodies.

Examples. Burning of a candle, rusting of iron, union of sulphur and iron, union of oxygen and hydrogen.

The fundamental principle on which we repose in all our scientific reasoning is, that *the laws of nature are constant*, or, in other words, that *like causes will always produce like effects.*

"The mode of reasoning, in physical science, which is the most generally to be adopted, depends on this axiom which has always been essentially concerned in every improvement of natural philosophy, but which has been more and more employed, ever since the revival of letters, under the name of induction, and which has been sufficiently discussed by modern metaphysicians. That like causes produce like effects, or that in similar circumstances similar consequences ensue, is the most general and most important law of nature; it is the foundation of all analogical reasoning, and is collected from constant experience by an indispensable and unavoidable propensity of the human mind." (Dr. Thomas Young's *Lectures on Natural Philosophy*, Lecture I., page 11. London, 1845).

"Most of the phenomena of nature are presented to us as the complex results of the operation of a number of laws."

Examples. In astronomy, in sound, in light, in heat and in electricity.

"We are said to explain or give the cause of a simple fact when we refer it to the law of the phenomena to which it belongs, or to a more general fact; and a compound one when we analyze it and refer its several parts to their respective laws.

"The indefinite use of the term cause has led to much confusion and error. We distinguish two kinds of causes, *intelligent* and *physical.*

"By an *intelligent cause* is meant the volition of an intelligent and efficient being producing a definite result.

"By a *physical cause*, scientifically speaking, nothing more is understood than the law to which a phenomenon can be referred.

"Thus we give the physical cause of the fall of a stone or of the elevation of the tides, when we refer these phenomena to the law of gravitation; and the intelligent cause (sometimes also called the moral or efficient cause), when we refer this law to the volition of the Deity."

[It is generally easy to know to what physical cause we should refer a class of physical phenomena; but what is often difficult, is to determine the nature and manner of acting of that cause, and to show how the phenomena and their laws are consequences of its properties. This is the nicest point in physical science.]

"In the investigation of the order of nature, two general methods have been proposed—I. The *à priori* method, and II. The inductive method.

"I. The *à priori method* consists in reasoning downwards from the original cognitions, which, according to the *à priori* philosophy, exist in the mind relative to the nature of things, to the laws and the phenomena of the material universe."

[Examples given of ancient and medieval *à priori* reasoning in their explanations of the motions of the heavenly bodies, and of the law of falling bodies.]

"II. The *inductive method*, which is the inverse of the other, is founded on the principle that all our knowledge of nature must be derived from experience. It therefore commences with the study of phenomena, and ascends from these to what is called the inductive process, to a knowledge of the laws of nature. It is by this method that the great system of modern physical science has been established. It was used in a limited degree by the ancients, and especially by Aristotle, but its importance was never placed in a conspicuous light until the publication of the *Novum Organum* of Bacon in 1620."

"In the application of the *inductive method* to the discovery of the laws of nature, four processes are usually employed.

"1. *Observation*, which consists in the accumulation of facts, by watching the operations of nature as they spontaneously present themselves to our view.

"This is a slow process, but it is almost the only one which can be employed in some branches of science; for example, in astronomy.

"2. *Experiment*, which is another method of observation, in which we bring about, as it were, a new process of nature by placing matter in some new condition."

[In making an experiment we should not only evolve the phenomena whose laws we wish to determine, but should also so produce these phenomena that we can *measure* their related parts.]

"This is a much more expeditious process than that of simple observation, and has been aptly styled the method of cross-questioning or interrogating nature.

"The term *experience* is often used to denote either observation or experiment, or both.

"3. *The Inductive Process*, or that by which a general law is inferred from particular facts. This consists generally in making a number of suppositions or guesses as to the nature of the law to be discovered, and adopting the one which agrees with the facts. The law thus adopted is usually further verified by making deductions from it and testing these by experiment. If the result is not what was anticipated, the expression of the law is modified, perhaps many times in succession, until all the inferences from it are found in accordance with the facts of experience."

[Examples of induction in the discovery, by Newton, of the law of gravitation; of the composition of light; of Wells' theory of dew; of Ampére's laws of electro-dynamics.]

"4. *Deduction*, which is the inverse of induction, consists in reasoning downwards from a law, which has been established by induction, to a system of new facts. In this process the strict logic of mathematics is employed, the laws furnished by induction standing in the place of axioms. Thus all the facts relative to the movements of the heavenly bodies have been derived, by mathematical reasoning, from the laws of motion and universal gravitation." (Prof. J. Henry.)

[*Examples* of deduction. The discovery of the planet Neptune by Leverrier and Adams, of conical reflection by Hamilton and Lloyd. Laplace's work, *Méchanique Celeste.*]

"Bacon's greatest merit cannot consist, as we are so often told that it did, in exploding the vicious method pursued by the ancients

of flying to the highest generalizations for it, and deducing the middle principles from them, since this is neither a vicious nor an exploded method, but the universally accredited method of modern science, and that to which it owes its greatest triumphs. The error of ancient speculation did not consist in making the largest generalizations first, but in making them without the aid or warrant of rigorous inductive methods, and applying them deductively without the needful use of that important part of the deductive method termed verification." (J. Mills' *System of Logic*, vol. ii., page 524–5.)

The agreement of the deductions, which we make from a law, with the facts of subsequent observations and experiments, is the only test of our having truly arrived at a law.

Bacon well remarked that the test of true science was its utility, and Franklin was well aware of this when a friend, asking him the use of electricity, he replied, characteristically, "What is the use of a baby?"

"When one system of facts is similar to another, and when, therefore, we infer that the law of the one is similar to the law of the other, we are said to reason from *analogy*.

"This kind of reasoning is of constant use in the process of induction, and is founded on our conviction of the uniformity of the laws of nature.

"In the process of the discovery of a law, the supposition which we make as to its nature must be founded on a physical analogy between the facts under investigation and some other facts of which the law is known. One successful induction is thus the key to another."

[*Examples.* Young's discovery of the interference of light; Franklin's of the identity of lightning and electricity.]

"A supposition or guess thus made from analogy as to the nature of the law of a class of facts, is usually called an *hypothesis* and sometimes the *antecedent probability*.

"When an hypothesis of this kind has been extended and verified, or, in other words, when it has become an exact expression of the law of a class of facts, it is then called a *theory*."

[Flourens, in his *Éloge sur Buffon*, says: "An *hypothesis* is the explanation of facts by possible causes; a *theory* is the explanation of facts by real causes."]

"Physical theories are of two kinds, which are sometimes called *pure* and *hypothetical*. The one being simply the expression of a law, which is the result of a wide induction, resting on experiment and

observation. Such is the theory of universal gravitation; the theory of sound.

"The other consists of an hypothesis combined with the facts of experience. Of this kind is the theory of electricity which attributes a large class of phenomena to the operations of an hypothetical fluid endowed with properties, so imagined as to render the theory an expression of the law of the facts." (Prof. J. Henry.)

A theory is therefore an assemblage of the facts and of the laws, with the consequences which may therefrom be deduced, which belong to one and the same physical cause. Thus we have the theory of gravitation; of light; of heat; of sound, &c.

A theory, to be true and complete, should explain to their minutest details all the phenomena produced by the cause, and that, naturally, without its being necessary to modify the given facts and their laws. Also the numerical results deduced by mathematical calculation should agree with those furnished by direct observation. If, moreover, the logical deductions which we obtain enable us to predict new phenomena which experience afterwards confirms, that theory carries with it the most convincing proof of its reality. The theory of gravitation and the undulatory theory of light afford us beautiful and instructive examples.

In order to establish a theory and follow logically the consequences of the principle from which we have started, we are obliged to compare among themselves quantities which are often bound together by very complicated relations. The unaided attention is not equal to such an effort, and hence we continually call in the aid of mathematical analysis to assist us in our investigations in physics.

"Strictly speaking, no theory in the present state of science can be considered as an actual expression of the truth.

"It may, indeed, be the exact expression of the laws of a limited class of facts, but in the advance of science it is liable to be merged in a higher generalization or the expression of a wider law.

"It should be recollected that the laws of nature are contingent truths, or such as might be different from what they are for anything we know —that they can only be established by induction from the facts of experience—that they admit of no other proof than the *à posteriori*, one of the exact agreement of all the deductions from them with the actual phenomena of nature, and that no other cause can be assigned for their existence than the will of the Creator.

"The ultimate tendency of the study of the physical sciences is the

improvement of the intellectual, moral and physical condition of our species. It habituates the mind to the contemplation and discovery of truth. It unfolds the magnificence, the order and the beauty of the material universe, and affords striking proofs of the beneficence, the wisdom and power of the Creator. It enables man to control the operations of nature, and to subject them to his use." (Prof. J. Henry.)*

From the London Mechanics' Magazine, August, 1867.

IMPROVED GIMLET.

EVERY one who uses the common gimlet knows that it is almost impossible to bore a hole with it without splitting the materials. Besides this, in hard woods, the tool works very unsatisfactorily, as the screw on the end draws out before the hole is completed. In any case the action of the gimlet is defective from the manner in which it is constructed. It is not a cutting tool, but performs its work by crowding or forcing the wood to one side.

Mr. E. P. Watson, of New York, has hit upon an invention, the object of which is to produce a gimlet that will bore without splitting, and cut as true a hole as an augur. In this instrument, the tapering portion is provided with a series of shoulders which form cutting edges, and remove chips as the screw on the end draws in. The object is attained perfectly, and the result is a much better tool at little additional cost of manufacture, and can be applied to gimlets already manufactured, either double or single cut. The advantages of this gimlet are apparent.

From the London Mechanics' Magazine, August, 1867.

ANIMAL POISONS.

IN some experiments on the poison of the cobra di capella, which George B. Halford, M. D., Professor of Anatomy in the University of Melbourne, has been lately engaged in, he has discovered that when a person is mortally bitten by the cobra, molecules of living "germinal" matter are thrown into the blood and speedily grow into cells. These cells multiply so rapidly that in a few hours millions upon millions are produced at the expense of the oxygen absorbed into the blood during respiration; and hence the gradual decrease and ultimate extinction of combustion and chemical change in every other

* In ¶I. we have made several long quotations from an admirable "Syllabus of a Course of Lectures on Physics," by Prof. Joseph Henry; for it was not in our power to have expressed these important fundamental truths so well, and we do not know of any work in which they are so concisely stated.

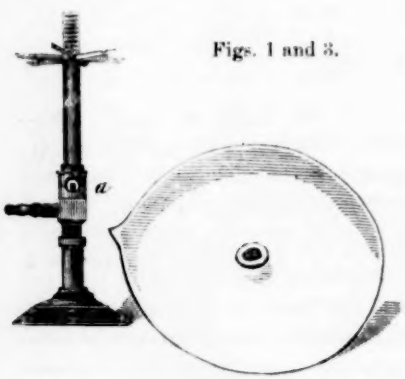
part of the body, followed by coldness, sleepiness, insensibility, slow breathing and death. The cells which thus render in so short a time the blood unfit to support life, as described by the professor, are circular in diameter, on the average of $\frac{1}{1700}$th of an inch. They contain a nearly round nucleus of $\frac{1}{2800}$th of an inch in breadth, which, when further magnified, is seen to contain other still more minute spherules of living "germinal" matter. In addition to this, the application of magenta reveals a minute colored spot at some part of the circumference of the cell. This, besides its size, serves to distinguish it from the white bus or lymph corpuscle. The professor adds to his account of the action of this powerful poison that he has many reasons for believing that the *materias morbi* of cholera is a nearly allied animal poison, and that if this, on further examination, should prove to be the case, we may hope to know something definite of the poisons of hydrophobia, small-pox, scarlet fever, and, indeed, of all zymotic diseases.

FLAME REACTIONS.

By Prof. Bunsen.

Translated by Prof. Charles F. Himes, Ph.D., Dickinson College, Carlisle, Pa.

Almost all the reactions obtained by means of the blow-pipe can be produced in the colorless flame of the gas-lamp (Bunsen's), and even with much greater ease and precision. The lamp flame has besides peculiarities not possessed by the blow-pipe, which can be employed for obtaining reactions through which the smallest traces of some substances which manifest themselves together may be detected when the blow-pipe and even more delicate means of analysis are of no avail.



Figs. 1 and 3.

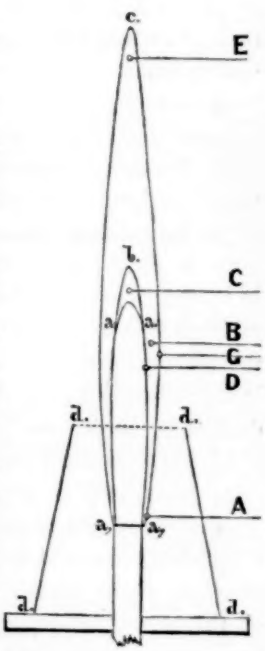
The number of reactions that can be obtained in this way is so great that only the principal ones are here given, and the further prosecution of the method described, in other directions according to near analogies, is left to those who desire to become more fully acquainted with the subject.

I. The Non-luminous Gas-flame and its Divisions.—The gas-lamp, Fig. 1, with colorless flame which serves for experiments upon

the reaction of substances, is three and a half times the size of the figure. It is necessary that it be made of the proper dimensions, and also be provided with a collar at *a*, by turning which the draft apertures may be closed or opened, and the access of air regulated for all sizes of the flame. It is quite as necessary that the conical chimney, *d d d d*, Fig. 2, through which the flame passes, should be of such dimensions that the flame may burn with perfect steadiness and uniformity. The flame is represented, Fig. 2, of half its natural size, and is composed of the three following principal parts:

A. *The dark nucleus*, $a_1\ a_1\ a\ a$, which contains the cold gas mixed with about sixty-two per cent. of air.

Fig. 2.



B. *The flame mantle* $a_1\ c\ a_1\ b$, formed of gas in combustion mixed with air.

C. *The luminous point*, *a b a*, which is not seen in the normal flame, when the draft-apertures are open; but when needed for reactions, can be produced of the required size by closing the draft-apertures.

In these three main divisions the following six places for conducting reactions are found:

1. *The base of the flame at* A. Its temperature is comparatively low, since the gas, in a state of combustion at this point, is cooled by the current of cold air from beneath, and the cold edge of the lamp-tube takes away a considerable amount of heat. If a mixture of substances which color the flame is placed in this part of it, it is possible, in many cases, to vaporize the more volatile alone for an instant, and thus obtain a coloration of the flame that would not be seen at higher temperatures, because obscured by that of other substances volatilized at the same time.

2. *The zone of fusion* lies at B, somewhat above the lower third of the entire flame, and equidistant from the exterior and interior borders of the flame mantle, where it is thickest. Since the highest temperature prevails at this portion, it is employed for testing the fusibility, volatility and luminosity of substances, and for all fusions at a high temperature.

3. *The lower oxidizing flame at* G, in the exterior border of the zone of fusion, is especially adapted to complete the oxidation of oxides dissolved in fluxes.

4. *The upper oxidizing flame at* E, is formed of the upper non-luminous point, and is most energetic when the draft-apertures are entirely open. The oxidation of the larger test specimens is accomplished in this part as well as the elimination of volatile products of oxidation, and generally all oxidations that do not require an excessively high temperature.

5. *The lower reducing flame at* D, on the interior border of the zone of fusion, next to the dark nucleus. Since the reducing gases at this point are still mixed with unconsumed atmospheric oxygen, some substances remain unchanged here that are deoxidized in the upper reducing flame. This part of the flame therefore affords very valuable indications which cannot be obtained by means of the blow-pipe. It is peculiarly adapted to reduction upon charcoal and in beads.

6. *The upper reducing flame* is formed by the luminous point at C, which appears above the dark nucleus upon diminishing the access of air by gradually closing the draft apertures (Fig. 1, *a*). If this point is rendered too large, a test-tube, filled with cold water, held in it, will become coated with soot, which should never occur. It contains no free oxygen, but is rich in white-hot separated carbon, and therefore possesses much more energetic reducing properties than the lower reducing flame. It is used especially for the reduction of metals desired in the form of incrustations.

II. Methods of Testing in the Different Parts of the Flame.

A. *Behaviour of substances by themselves at high temperatures.* This is one of the most important indications for detecting and distinguishing substances. The possibility of producing, by means of the lamp alone, as high or even higher temperature, than by means of the blow-pipe, depends entirely upon rendering the radiating surface of the substance to be heated as small as possible. The apparatus, by means of which the test-specimen is placed in the frame, must, therefore, be taken as small as possible. The platinum wire on which the substances are heated, should scarcely exceed a horse-hair in thickness, and *a piece a decimetre long should not weigh more than* ·034 *grammes.* With thicker wire, all attempts to obtain the reactions described in the following pages will be in vain. Substances that attack the platinum wire, or that will not adhere to the moistened point, are held in the flame on a fibre of asbestus, hundreds of

which can be split from a moderately thick stiff fibrous piece. The thickness of these fibres should not exceed one-fourth that of a common friction match. Substances which decrepitate should be crushed upon the porcelain lamp-plate, Fig. 3, to the finest powder by means of the elastic steel blade, *a*, of the knife, Fig. 4, and then be soaked up on to a moist strip of filter-paper about a square centimetre in surface. After burning this paper, by holding it in the flame, by means of a platinum forcep, or, better still, between two rings of very fine platinum wire, the substance will remain behind as a coherent crust which can be treated in the flame without difficulty.

Fig. 4.

When bodies are to be held in a particular portion of the flame for some time, a holder, Fig. 5, is used. The arm, *a*, is fastened to the movable support, A, which turns and slides up and down upon the vertical rod against which it is pressed, as may be seen at B, by means of a weak spring. Upon this arm the small glass-tube, Fig. 6, is stuck, into which the platinum wire to be heated has been fused. Asbestus fibres are stuck into the glass tube, *b*, Fig. 5, which has a movement back and forth in the collar of the support, A, in addition to those of the arm, *a*, on the vertical rod. The similar movable support, B, on the same vertical rod, Fig. 5, has an arm with a clamp for the reception of test-tubes, which are to be heated for a considerable time in a particular part of the flame. The small revolving plate, C, is provided with nine pins, which serve to hold the glass tubes, Fig. 6, when in use or about to be laid aside. By means of this apparatus, a few particles of the substance to be tested are placed in the flame, and their behaviour noticed from the lowest up to the highest

Fig. 5.

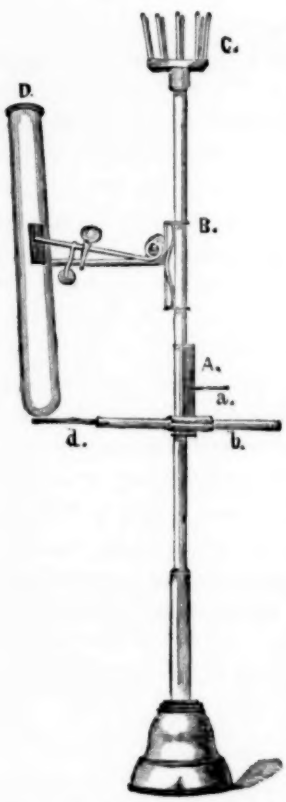


Fig. 6.

temperature, the test-specimen being examined after every change of temperature by means of a lens. The temperature in heating may be expressed by the six following grades, which may be estimated with sufficient accuracy, according to the luminosity of the platinum wire on which the test-specimen is held, or of one which may be introduced especially for the purpose.

1. Below red heat.
2. Incipient red heat.
3. Red heat.
4. Incipient white heat.
5. White heat.
6. Radiating white heat.

It need scarcely be stated that these grades of temperature can never be estimated from the luminosity of the specimen itself, as the brightness of bodies, *substantially different*, depends not so much upon the temperature as upon their specific power of emitting light.

Upon heating the substance, the following appearances are to be noticed:

1. *The Emission of Light.*—Substances are tested as to their power to emit light by bringing them on platinum wire into the hottest portion of the zone of fusion. The specimen is of low power if it becomes less luminous than the platinum wire, of medium if both seem equally bright, and of higher power if it exceeds the platinum in brightness. Most solid bodies emit a white light, others, as erbia, colored. A few compounds, as some of osmium, of carbon, of molybdenum, &c., volatilize, and give off finely divided solid particles which render the whole flame luminous. Gases and vapors always manifest a lower power of emission than fused substances, and these generally less than solids. In these tests the form of the test-specimen is always to be noted, since the power of emission depends essentially on the nature of its surface. Thus, for example, compact alumina, as it is obtained from the hydrate by gradual elevation of the temperature, has only a medium power of emission, whilst the spongy, porous kind, obtained by rapid ignition of the sulphate, has, on the contrary, a very high power.

(To be continued.)

From the Proceedings of the Royal Society, No. 92.

METHOD OF QUALITATIVE ANALYSIS OF ANIMAL AND VEGETABLE COLORING MATTERS BY THE SPECTRUM MICROSCOPE.

By H. C. Sorby, F. R. S., &c.,

1. *History.*

My attention was first directed to this subject by reading a report of Professor Stokes' very excellent lecture at the Royal Institution, Friday, March 4th, 1864. It immediately occurred to me that a spectroscope might be combined with a microscope, and employed to distinguish colored minerals in thin sections of rocks and meteorites. I was soon led to examine many other colored substances, and found that the instrument is more useful in connection with qualitative analysis, when only very small quantities of material can be obtained. At first I employed the imperfect apparatus described in my paper in the *Quarterly Journal of Science;** but afterwards, along with Mr. Browning, I constructed that described in my paper in the *Popular Science Review.*† For general purposes, I do not think that this could be much improved; but for chemical testing it is much less fatiguing to use a binocular instrument. There were many difficulties to contend with, but at length I constructed one which appears to answer all the requirements of the case.

2. *Apparatus.*

I have an ordinary large binocular microscope, and use an object-glass of about 3 inches focal length, corrected for looking through glass an inch thick, the lenses being at the top, so as to be as far as possible from the slit. This is placed at the focus, and between it and the lenses, at a distance of about half an inch from them, is a compound prism, composed of a rectangular prism of flint-glass, and two of crown-glass of about 61°, one at each end. This arrangement gives direct vision and a spectrum of the size most suitable for these inquiries, since a wide dispersion often makes the absorption bands far too indistinct. In order to be able to compare two spectra side by side, a small rectangular prism is fixed over half the slit, and with the acute angle parallel to and just passing beyond it. This gives an admirable result, the only defect being, that, when the spectra are in focus, their line of junction is some distance within it; and therefore to correct this I use a cylindrical lens of about 2 feet focal length, with its axis in the line of the slit, which can easily be fixed at such a distance between the slit and the prisms, as to bring the spectra and their line of contact to the same focus. In front of the slit, close to the small rectangular prism, is a stop with a circular opening, to shut out lateral light, and a small achromatic lens of about half an inch focal length, which gives

* April, 1865, vol. ii., page 198. † Vol v., page 66.

a better field, and counteracts the effect of the concave surface of the liquids in the tubes used in the experiments, if they are not quite full. These are cut from barometer-tubes, having an internal diameter of one-seventh of an inch, and an external diameter of about three-sevenths of an inch. They are made half an inch long, ground flat at each end, and fixed with Canada balsam on slips of glass 2 inches long and about six-tenths of an inch wide, so that the centre of the tube is about one-fourth of an inch from one edge. By this arrangement the liquid may be examined through the length of the tube, by laying the slip of glass flat on the stage of the microscope, or through the side of the tube, by placing the slip vertical and the tube horizontal. Cells of this kind can be placed upside down and deposits removed without any liquid being lost; and the upper surface of the liquid is sufficiently flat, even when inclined at a considerable angle. If requisite, small bits of thin glass can be laid on the top, which are held on by capillary attraction, or may be fastened with gold-size, if it be desirable to keep the solution for a longer time. When the depth of color is too great in the line of the length of the cell, we can at once see what would be the effect of about one-fourth of the color by turning it sideways; and thus we can save much time, and quickly ascertain what strength of solution would give the best result. Very frequently we obtain an excellent spectrum in one direction with one reagent, and in the other with another, without further trouble. I have constructed a small stage, too complicated to describe in writing, which enables me at once to examine solutions in two such tubes, either endways or sideways, and compare their spectra side by side, or to use test-tubes, or to fix the small apparatus which I have contrived for accurately measuring the spectra. This is of such great importance in these inquiries that I must describe it in some detail.

3. *Scale of Measurement.*

It consists of two small Nicol's prisms, and an intermediate plate of quartz. If white light, passing through two such prisms, without the plate of quartz, be examined with the spectrum microscope, it of course gives an ordinary continuous spectrum; but if we place between the prisms a thick plate of quartz or selenite, with its axis at 45° to the plane of polarization, though no difference can be seen in the light with the naked eye, the spectrum is entirely changed. The light is still white, but it is made up of alternate black and colored bands, evenly distributed over the whole spectrum. The number of these depends on the thickness of the depolarizing plate, so that we may have, if we please, almost innumerable fine black lines, or fewer broader bands, black in the centre and shaded off at each side. These facts are, of course, easily explained by the interference of waves. It would, I think, be impossible to have a more convenient or suitable scale for measuring the spectra of colored solids and liquids. If we use a micrometer in the eye-piece, an alteration in the width of the slit modifies the readings, and the least movement of the apparatus may lead to

error, whereas this scale is not open to either objection. Besides this, the unequal dispersion of the spectrum makes the blue end too broad, so that a given width, as measured with a micrometer in the eye-piece, is not of the same optical value as the same width in the red. The divisions in the interference spectrum bear, on the contrary, the same relation to the length of the waves of light in all parts of the spectrum, and no want of adjustment in the instrument alters their positi on. As will be seen from the drawing (Fig. 1), the unequal dispersion makes the distance between the bands in the blue about twice as great as in the red. The perfection of a spectrum would be one in which they were all at equal intervals; but possibly no such uniform dispersion could be produced. By having a direct vision prism, composed of one of flint-glass of 60°, and two of crown-glass of suitable angle, we can place it over the eye-piece, and may diminish the dispersion at the blue end, or increase that at the red end, by turning it in one position or the other, and thus see either end to the greatest advantage. It is, of course, very easy to draw spectra on this principle, and give all parts equal prominence, and not an unduly compressed red, and an unduly expanded blue end. Thus drawn, the spectra are far more uniform in many of their characters, and some general laws are at once apparent that otherwise might have been entirely overlooked; and on this account I shall adopt this system in those figured in this paper. It is, in fact, merely representing the actual measurements by drawings, without being at the trouble of distorting them, so as to be like naturally distorted spectra.

(To be continued.)

From the London Engineering, September, 1867.

THE FIFTEEN INCH ARMOR-PLATE.

Sir John Brown has signalized his new knighthood, by rolling an armor-plate 15 inches thick, and weighing 21 tons, a plate over 20 feet long and four feet wide. The plate is pronounced sound, although this can only be fully ascertained by cutting it up, and it is not impossible that a portion of it may be brought under the fire of the 9 inch gun, firing Palliser shot. The plate, it is to be remembered, was produced with the same furnaces and rolls as those put up for making 4½ inch to 9 inch plates, and it cannot, therefore, be said to represent any new attainment in the means of producing heavy plates. Such plates have not been, heretofore, rolled, only because they have not been asked for. No ship, yet built, could carry them; but it is now possible that they may be adopted for casing forts. Messrs. Cammell & Co. have already made sample plates 14 inches thick, and, with the same plant, it is, of course, as easy to roll a 15 inch plate at the Cyclops Works, or at Barrow, as at the Atlas Works. The one rolled on Friday, con-

sisted of five 3 inch and one 6 inch plates, laid up in a pile 21 inches thick, and welded together by rolling down with a reduction of hardly more than one-fourth the original total thickness. The absolute reduction in thickness is, indeed, hardly greater than that in rolling 4½ inch plates, which are rolled down from four 2½ inch plates, piled together, and having, therefore, a total thickness of 10 inches. To bear this distinctly in mind, is in no way to really disparage the feat of rolling a 15 inch plate; but we are not to forget that there are uninformed persons who imagine that the difficulty in making tough rolled plates increases at least in proportion to their thickness; if not, like their resistance to shot, as the square of their thickness. Only let the War Office, or the Admiralty order 15 inch plates, and a number of firms would be found ready, with long existing plant, to supply them.

The *Times* has a really clever article, describing the rolling on Friday last—an article after the manner of Victor Hugo, and likely to produce a sensation, and a desirable and genuine sensation, among the multitude, who know so little of iron-making It hardly needs correction where it says the plates are rolled between *steel* rollers, as our readers know they are of chilled iron. The *Times* gives the credit of the victory of rolled *vs.* hammered plates to the Atlas Works, not undeservedly, we think. But we are reminded of the effusion of a certain poetic wag, in Sheffield, in 1861, who sang to the air of "The King of the Cannibal Islands:"

> "Now hammer'd iron's brittle stuff;
> When roll'd, it 's fibrous, strong and tough—
> At least they say so—that's enough—
> At the Atlas Steel and Spring Works."

The article to which we have referred thus describes the provisions for obtaining a good heat among the slabs of which the single plate is formed:

"One of the great difficulties in making these thick armor-plates, was found to be that of securing a uniform heat—that is to say, a heat which should penetrate to the centre of the mass, so as to secure a perfect weld, without being so great and long sustained as to melt the upper layers. This difficulty is overcome most ingeniously at the Atlas Works. Between each layer of slabs a number of cubes of highly carbonized iron, about an inch square, are placed, so as to keep each slab apart from the others. This allows the whole mass of flame and heat to circulate freely between them, so that all attain the same degree of heat at almost the same time. As the intense ardency of the furnace increases, these cubes are gradually melted. In the act of melting they restore to a certain degree the carbon which has been burnt out of the slabs by previous processes, and, as they melt, allow each slab to settle down, when, like a cement, their melted metal forms a perfect weld. It is not till this has been effected, and the now perfect plate is heated to an almost blinding whiteness, that the mass is withdrawn from the furnace and has to be rolled."

EDUCATIONAL

(Continued from page 281.)

THE MAGIC LANTERN AS A MEANS OF DEMONSTRATION.

WE have said much about the correction of condensers with regard to spherical aberration, and some may ask why not correct them for chromatic aberration, as well. We answer, for two reasons—1st, because it is practically impossible, that is, the cost would be enormous, and shortness of focus unattainable; 2d, because it is not necessary. The condenser is not intended to produce an image, but simply to concentrate a bundle of rays and pass them in a certain way, through the object and objective. Though each point of the lens may produce a spectrum, these spectra will over-lap each other and re-combine into white light; except at the edge, this extreme portion alone, therefore, is colored, and needs to be cut off by the mounting of the objects or other masses.

A corrected condenser certainly would be better, could we get it without drawback, as we see in the table microscope, but can be well dispensed with in the lantern.

Objectives.

We propose, under the above head, to give a very full discussion of the merits of various objectives, both for the lantern and gas microscope, and to develop certain new principles and their practical results, in such a way as will, we believe, be very useful to many who are interested in this subject.

Before treating in detail of these matters, it will be necessary to explain some points about the relations of condensers and object-glasses, which have been very generally overlooked, and are essential to the correct appreciation of the present subject.

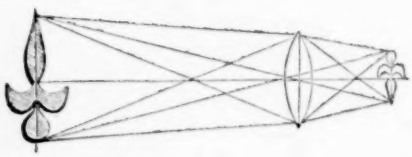
It is very common to say of object-glasses, that they produce enlarged images of the objects illuminated by the condensers, exactly as any ordinary lens makes an image of an object, or very much as the lens of a camera produces its picture.

To test the correctness of this statement, try the following experiments: Take an ordinary bull's-eye, such as is used for an illuminator, with the table miscroscope, and see what sort of image it will make

of a distant object, reducing it, or of a near one, enlarging it, as in the physioscope. The image produced, especially with the curved side of the lens toward the object, will be so utterly distorted, discolored and confused as to be almost unrecognizable. Now, place this same lens as an objective, in a good lantern, and I venture to say you will be surprised at the effect. We do not mean to say that it will produce such a result as can be obtained with corrected lenses, but only that it is incomparably better than would have been anticipated. Here then we see that some new element has been introduced, and we cannot do better than study it, for it is clearly of vital moment.

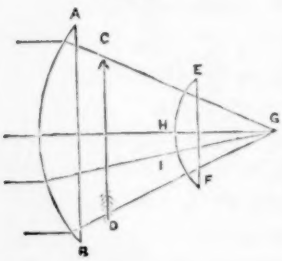
In fact, it is simply this: While in the ordinary formation of an image by a lens, *countless rays* from each point of the object go to *every part* of the lens, to be by it concentrated, with more or less accuracy, in the corresponding points of the image. (See Fig. 15.)

Fig. 15.



In the lantern, on the other hand, the converging rays from the condensers are modified by the object in passing through it as to color and intensity, but not as regards direction, and thus fall upon the objective in such a manner that a *single ray* only (we here speak theoretically, and without the limitations to be stated in a moment) from each part of the object, strikes the objective and *each ray* at a different point. It, therefore, follows in this case, that each point of the image is formed by a single small part of the lens, in place of the whole lens, and we reach a result similar in many respects to that produced by the "stop," when used with lenses in the ordinary way, but here no loss of light is entailed.

Fig. 16.



This is illustrated in Fig. 16, where A B is the front of the condenser, E F the objective, C D the object, and A G, B G, &c. the rays which are to form the image after treatment with the object-glass.

The errors in the image are, therefore, almost reduced to the errors, not of the entire lens, but of very small lenses, depending for their

area upon the accuracy (in correction) of the condenser. Were the source of light, then, a point, and the correction of the condenser, perfect, an almost perfect image would be formed by a common lens. We say *almost*, for there would still be the error which does not depend upon want of correction in the ordinary sense, namely, want of flatness of field, and the error due to what we may call the *prismatic* arrangement of the supposed minute lenses; that is to say, their disposition on a spherical shell with varying thickness of glass, by reason of which each may be considered as a lens plus a prism.

The above description will, no doubt, recall to many the account of Zentmayer's lens, published in this *Journal*, vol. lii. page 63.

There is, in fact, the closest relationship between the conditions obtained in the two cases; in one, by acting from within with the central stop; and in the other by preliminary treatment and preparation of the light, before it enters the lens, the same result being obtained in either case, namely, that the lens acts by detachments concentrically arranged.

The above considerations will show that, if we proceed with the correction of objectives for the lantern and gas microscope, on the same principles and by the same methods as are applied to lenses used, such as are fit for telescopes, cameras and table microscopes, we are at least doing useless work and sacrificing what might be otherwise secured.

This, then, is our theory of the subject, which we have practically developed already in one direction, and hope, as opportunity may offer, to carry further.

Low-power objectives, such as are used in the mere magic lantern, should, for many purposes, be simple plano-convex lenses, with their curved face towards the object. The point of advantage gained is a greater amount of light transmitted to the screen, and hence greater brightness of effect. The drawback is want of sharp definition, presence of colored fringes and lack of flat field.

We, therefore, use these lenses in cases where the first item is of paramount value, or where the others are sacrificed at any rate, from other causes. Thus, in all tank experiments, the thickness of the object renders nicety of definition out of the question, and the nature of the experiment makes this quality inappreciable if it were present.

Again, in very large buildings everything should be sacrificed to brightness, because this can be appreciated by all, while few if any of the audience are near enough to see the errors of definition, &c., which may exist.

With regard to instruments which are to be employed in such a way that greater precision will be appreciated, and is, therefore, requisite, we can recommend, in the existing state of optical manufactures, as the first step in improvement upon the common lens or combination of two uncorrected lenses, the front lenses of the better class of opera glasses. For a yet more perfect definition (though this must be purchased by a further small sacrifice of light), the next step is to employ a photographic portrait combination, of short focus, such as the quarter-sized tubes of Jamin or Voightlander.

These things we recommend only because they are at present the only attainable instruments, but we believe that the time is not far distant when a lens will be produced, which will (by reason of a special adaptation to the conditions of the case) afford at once the two important results of flatness of field and brilliant illumination.

In the way of microscopic objectives, we have already realized a greater success than we had ventured to anticipate. Thus, with a a 9-10ths objective, modified by Mr. Zentmayer from his usual form, in accordance with the general principles already set forth, we have been able to cover a screen of 12 feet in diameter with a brilliant and even disk of light, on which the microscope specimen shows with *artistic relief* from the *strength* of *contrast;* as is the case with appropriate subjects in the magic lantern.

We have given considerable space to the above discussion because it is a subject of vital importance, both in a theoretical and practical relation, and has clearly been frequently overlooked or misapprehended by those who have written upon the subject, even when they have been the most eminent authorities in optics. Thus, in the splendid work of J. Jamin, Professor of physics in the *Ecole Polytechnique*, one of the most able and thorough treatises yet published, we find on page 741 of volume iii. that the author has "nodded" over this very subject and has given a drawing, which he would be the first to laugh at, if his attention were called to it. In this the light and object are represented as being in the *conjugate foci* of the condenser; one among many other undesirable consequences of which would be, that when the object-glass was properly adjusted to give an image of the object, it would also give one, of the light, derived from the ærial image of the same, formed by the condenser in the plane of the object.

Where so great an authority commits an oversight, we may naturally expect to find similar mistakes among lesser lights, as is indeed the case in the present instance.

(To be continued.)

NOTES OF APPARATUS AND EXPERIMENTS

Devised by ALFRED M. MAYER, PH.D.,
Professor of Physics in the Lehigh University.

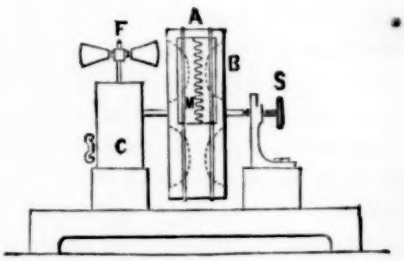
1. *Apparatus for registering and exhibiting the vibrations of rods, for obtaining the number of their vibrations in one second, and for determining their laws of vibration.*

The idea of causing a vibrating solid to register its vibrations on a revolving cylinder, although claimed by Duhamel and others, originated really with Dr. Thomas Young, who, in 1807, described minutely such an apparatus, with an accompanying plate, in his "Lectures on Natural Philosophy and the Mechanical Arts." (See 2d edit. London, 1845, page 146.)

The object of the form of instrument which I here describe, is to give results which can be exhibited to a large audience when we project its registrations on a screen by means of a lantern; and at the same time to furnish the physicist with an instrument of precision at a small cost.

The following is a description of the apparatus: C is a train of wheel-work whose velocity is regulated by turning the vanes of the fly F, so as to present more or less resisting surface to the air. A prolonged axis of one of the wheels carries with it the cylinder, A (about 8 ins. diam.), on which is fastened with two wires, or with two india rubber strings, a thin piece of mica, M, exactly $\frac{1}{4}$ or $\frac{1}{8}$ or any known part of the length of the circumference of the cylinder. This slip of mica, before being bound to the cylinder's surface, is covered with a fine film of lamp-black by smoking it with burning camphor. The fork or rod, the number and *form* of whose vibrations we wish to obtain, is screwed into a wooden rod, A (Fig. 2.), or is clamped in a vice whose jaws are covered with chamois skin. This rod is hinged at the other end to the plane of the base of the apparatus. The fork has stuck on its end with wax a fine stiff wire with a fine *rounded point*, as shown at W. When the cylinder has an uniform motion and a known time of rotation, the fork is pressed down on the piece of wood, K, whose end is covered with kid; and on relieving it of pressure it flys up, from the tenison on the

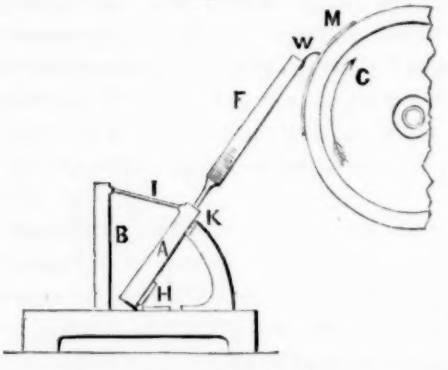
Fig. 1.



india rubber band, I. We can thus with precision bring the vibrating wire to touch momentarily the revolving cylinder and cause it to leave its vibrations in a sinuous line, described by its point scraping off the lamp-black from the curved mica plate.

The mica detached from the cylinder unbends into a plain surface, and is now placed in the electric lantern; when, with a focus of from 30 to

Fig 2.



50 feet, we can readily and accurately obtain on a screen, projections of the curves, the amplitude of whose flexures are often a foot or more in height.

An audience of many hundreds can thus count for themselves the number of vibrations in, say, $\frac{1}{8}$ of the circumference, and, knowing the time of revolution of the cylinder, at once have the number of vibrations which the fork or rod makes in one second.

So much for the apparatus as a means of illustration. To use it as an instrument of precision in investigation, the time of revolution of the cylinder has to be accurately determined. For that purpose the end, B, of the cylinder is painted white, and pasted on it is a slip of red paper, which extends from the circumference, radially, to within about two inches of the axis. A white screen, perforated with a vertical slit equal in width to the width of the slip of red paper, is placed close to the plane of the end, B. Whenever the red slip comes before the slit, a red band suddenly and vividly appears and marks one revolution of the cylinder. The apparatus is placed with the face, B, fronting the light. The clock-work is wound up and the vanes adjusted so that the flexures of the sinuous line will not be too close together nor too much separated. After the cylinder has run for one minute, we can consider the motion as uniform, and then we commence and count with a stop-

watch the time taken for 100 bright red bands to appear on the white surface. This time, divided by 100, will give us the time of one revolution of the cylinder to within $\frac{1}{100}$th of the error made in determining the time of 100 revolutions. Thus, if we suppose an error of 1 second (which is far too great ever to happen) in the time of 100 revolutions, the time of one revolution is given with an error of only $\frac{1}{100}$th of a second.

The clock-work is again wound up, and after the cylinder has revolved *one minute and a half*, the wire-armed fork is momentarily depressed; the wire comes in contact with the mica surface and the curves are described. Knowing the part of the circumference occupied by the mica and having the time of one revolution, by proportion we readily calculate the number of vibrations made in one second.

The fork ut^3 (the lowest c of the violin) gives 512 simple vibrations in one second; and suppose, for simplicity of illustration, that the cylinder, A, makes one revolution in one second, then, if the mica slip is $\frac{1}{8}$ of the circumference in length ($\frac{1}{8}$ of the circumference is about 3 ins.) there will be traced on the blackened mica 64 undulations, each of which undulations was described in the $\frac{1}{512}$th part of a second.

After the fork has ceased to vibrate, rest the wire point, with which it is armed, gently on the mica and revolve the cylinder; a straight line will be traced bisecting the undulating line in the direction of its length, and the portions of the curves on one side and on the other of the median line will show the extent of the vibrations on one side and the other of the position of equilibrium.

If we place in the lantern a plate having a square aperture of, say, $\frac{1}{10}$ of an inch, we can, by measuring its image when brought to a focus on the screen, determine with accuracy the magnifying power of the lantern's lense, and detect and allow for any aberration of sphericity which it may have. After this, we can deduce from measures made on the image of the curves, the amplitude of the oscillations of the fork.

One of the undulations on one side of the median line can be very accurately traced on the screen, or its image photographed by using the magnesium light. Now, divide that part of the median line included between the two branches of the undulation into 10 equal parts, then each of these parts stands for the $\frac{1}{5120}$th of a second, and perpendiculars drawn to the curve from these divisions show how far the fork had moved in any number of $\frac{1}{5120}$ths of a second!

From these measures we can deduce the law of the vibration. We are at present engaged on a discussion of curves produced by rods of

various forms of transverse section; of different lengths; loaded at various points, &c., &c. We find that, in general, the undulation has the form of the *sinusoid* ($y = sin.\ x$).

With this apparatus can also be solved all questions relating to the times of oscillation corresponding to different amplitudes of vibration.

An interesting experiment is to arm both prongs of a fork with wires, and then for the result on the mica slip we have two sinuous lines, the concavities and convexities of the two curves being opposed to each other.

If four forks, giving the four notes of the *perfect major accord*, C, E, G and C of the octave higher, are made to describe their curves on the mica slip and are then placed in the lantern, their projected images on the screen will directly show in the most beautiful manner that their vibrations are to each other respectively as 4 : 5 : 6 : 8, by simply drawing two vertical lines through all the four sinuous lines; which, if they include four undulations made by the fork, C, will also inclose five undulations of the fork E, six of the fork G, and eight of the fork C of the next octave higher.

We should have mentioned that the cylinder is made of very dry wood, which is, after being turned, placed in a solution of shellac in alcohol, under the exhausted receiver of an air-pump, and thus it is so saturated with the varnish that it does not change its form from the absorption or loss of moisture. The cylinder may be made lighter by turning out the wood on its sides from an inch from the axis to within one inch of the circumference.

2. *An insulating support for a vibrating bell when under the receiver of the air-pump.*

The fundamental experiment of the inaudibility of a vibrating bell, while in the vacuum of a good air-pump, sometimes does not succeed, and the failure can nearly always be attributed to the want of perfect insulation of the vibrating apparatus inclosed in the receiver.

After numerous experiments, we find that the best insulating support for the sounding apparatus is made of a plate of wood having its feet of the reddish india rubber used for erasing. This article has its surface pitted with square depressions, so that when it is cut into cubes for the support of the wooden plate, the surface which touches the plate of the air-pump finds few points of contact.

The rubber is cut into cubes, which are melted on one of the pitted surfaces by contact with a hot iron, and then immediately applied to the wooden plate; they are thus securely cemented to the wood.

3. To succeed with *Wheatstone's interference experiment*, place the two branches of the ⅄ one over a + sector of a vibrating plate, the other over a — sector. Now, if the sand on the membrane covering the upright tube of the ⅄ be of the *proper quantity* (which depends on the tension of the membrane), and *heaped in the centre of the membrane*, no motion of the sand or sound of the pipe will be produced; but if one branch of the ⅄ be placed over a + and the other branch over a + sector of the vibrating plate, the sand will sing on the membrane and the heap will run down on the plane of the membrane.

4. *Experiment to show the non-conductivity of liquids.*—A glass cylindrical vessel containing water is perforated by thermometer tubes at different points down its side. The water quite fills the vessel, and after all agitation has ceased, a broad oxyhydrogen blow-pipe flame, issuing under a feeble pressure, is brought to play upon the tranquil surface. This flame has intense heating power, but radiates little, if any, through the liquid. The surface of the water seethes and a quantity of vapor rises in the air; but the thermometer quite near the surface is not affected.

On plunging the finger in the liquid the hot *surface-water burns* in a circle round the finger, while the tip of the finger is in cold water.

The old experiment of inflaming ether on the surface of the water is merely fit to amuse children; it proves nothing.

5. *A good vessel in which to freeze water in vacuo*, is made by burning a concavity in a plate of cork by rotating on it a red-hot cannon ball. If the quantity of water be not large it does not wet the burnt surface; and this fact, together with its non-conducting property, renders it a more proper vessel than the usual *metal* dish.

We generally place four of these cork dishes under the pump supported on a thin wire frame, or on a support made of wooden strips.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, September 18th, 1867.

THE meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meetings in July, August and September, donations to the Library were received from the Royal Astronomical Society, Royal Geographical Society, the Society of Arts, the Chemical Society, the Institute of Actuaries and the Statistical Society, London; the Association for the Prevention of Steam-Boiler Explosions, Manchester, England; Thos. Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta, India; la Société d'Encouragement pour l'Industrie Nationale, l'Academie des Sciences, l'Ecole des Mines, Paris, and la Société Industrielle, Mulhouse, Paris; da Osterreichischen Ingenieur-Veriens, da Niéder Osterreichischen Gewerbe-Verien, Vienna, Austria; Rear Admiral C. H. Davis, U. S. N., Commodore B. F. Sands, U. S. N., Superintendent U. S. Naval Observatory, Wm. J. Rhees and the Department of Education, Washington, D. C.; Hon. Chas. Sumner, of Massachusetts; the University of Mississippi, Oxford, Miss.; Franklin E. Felton, Vallejo, California; the Managers of the Lunatic Asylum, Utica; and the Chamber of Commerce, City of New York; A. Roebling, Trenton, N. J.; John C. Trautwine, Esq., and Charles Bullock, Esq., Philadelphia. To the Cabinet of Minerals, &c., from J. C. Murphy, Dr. Frederick A. Genth, Philadelphia.

The various Standing Committees reported their minutes.

The Special Committee on Experiments in Steam Expansion reported progress.

The report of the Resident Secretary was then read, at the conclusion of which Mr. Robert Briggs announced the death of Mr. George Erety, one of the Vice-Presidents of the Institute, and offered the following resolutions:

Whereas, George Erety, one of the Vice-Presidents of the Institute, departed this life on the 10th day of August, 1867, after an active and useful membership with us for many years, and his worth and services demand a fitting perpetuation on our records; therefore

Resolved, That the members of the Institute, sincerely deploring his removal in the midst of a career devoted to the best interests of the community in which he lived, desire hereby to express their sorrow for his loss and their great esteem for the zeal he always manifested for the welfare and prosperity of the Institute.

Resolved, That the Secretary be requested to furnish a copy of the proceedings to the family of Mr. Erety, and to express our sympathy with them in their bereavement.

The above resolutions were, on motion, duly adopted, after which the meeting adjourned. HENRY MORTON, Secretary.

Report of Committee on Safety-Valves and Steam-Gauges.

The Committee, to which was referred the consideration of the legal requirements which should be made for safety-valves and pressure-gauges upon steam-boilers, ask leave to

REPORT.

Considering, first, the subject of safety-valves—

We do not find there has been acknowledged in American or English practice of engineers or boiler-makers, any general rule of dimensions of safety-valves, relating to other dimensions of boilers, or to the pressures of steam or the rates of combustion of fuel, although such relationship is admitted by the assumption and use of different constructors without any definite rule.

Neither have those writers in our language, whose works are regarded as authoritative upon the subject of steam and the steam-engine, nor has American or English legislation established or stated suitable proportions and requirements for the various conditions. On the other hand, the laws of France and of other continental nations have been framed with an evident appreciation of the essential demands; and establish areas of valve-openings for all sizes of, and pressures of steam in, boilers, so that it has only remained for the Committee to translate into English measures, to modify the ratios by using as the surface of comparison with the safety-valve area, the grate surface in place of that adopted by the French—the boiler surface—and to make a further correction by embracing in the rule the differing rates of combustion upon the grate surface.

The Committee have not found, nor have they sought very carefully, the reasoning upon which the French rule or formula has been based, and will say that they reached the same conclusion independently, and were not a little surprised by the coincidence after their own investigation. We proceed to give, as briefly as possible, those considerations which control or influence this question of area of safety-valves. A safety-valve is a loaded valve covering an orifice-opening outwards from a boiler, which valve is intended to lift whenever the pressure of steam within the boiler rises above that to which

the valve has been loaded, and the opening thus produced ought to discharge the steam of the boiler in such quantities that the pressure within shall not exceed, to any considerable degree, or beyond some fixed limit, the defined pressure at which the valve opened.

Upon this proposition it is evident that a safety-valve may sometimes be required to discharge all the steam, which, under the most favorable conditions, may be formed by evaporation in any given time. As the rapidity of evaporation of water is evidently the result of rapidity of combustion of fuel, which itself refers to extent of grate-surface and strength of draft or blast (supply of air), we take the grate-surface or area as that element of a steam-boiler presenting the most readily measured surface for comparison with the required area of the opening or least section of the aperture or channel of discharge of an opened safety-valve. We can assume that the draft or supply of air to the fuel being burned under any given steam-boiler, is, on the average, that existing in ordinary stationary steam-boilers with chimney draft, and afterwards correct our proportions for forced draft or blast and more active combustion. In like manner, we can modify the results based on this assumption to suit the conditions of boilers which are heated by the waste heat or by the burning of gases unconsumed in manufacturing processes. As it is the object of this investigation to determine that area of safety-valve needed to ensure safety, it is proper to give so great an excess above the absolute demand for the sectional area of the vein of steam escaping from a boiler under any given pressure as will be sure to cover the emergency of extraordinary rapidity of combustion during any short period of time, and also to include the coefficient of resistance to discharge through a passage offering as much resistance as the one formed by lifting a disk-valve of the ordinary construction from a flat seat.

We here notice that there may be so large an excess of area that the opening of the valve may, by its sudden relief of pressure and discharge of steam, especially in boilers with limited water surface for the elimination of the steam from the water, dangerously disturb the equilibrium of circulation of water within the boiler; and also that the safety-valve may be so badly formed, in regard to shape of disk and seat, that, after lifting a little without any change of load upon the valve, the pressure within the boiler may dangerously increase, while a small quantity of steam only is discharged. In both of these points of difficulty we will refer to the practice of engineers, only saying here that the ratio of excess which we assume, when applied to the case of the

gradual rising of temperature and pressure which occurs in a boiler containing a mass of water, and only admitting the gradual opening of the valve, is much below any dangerous condition, and our assumed excess is really additional safety. The assumption of considerable excess also allows us, when in our theoretical examination we find considerations of obviously very small value, to reach, in a practical form, a perfectly satisfactory general result. Proceeding on these grounds, therefore, let us take the average combustion of a well set or arranged boiler at eight pounds of coal (or fuel equivalent) per square foot of grate per hour, and that the maximum combustion, when the fire is in the best condition, and is evolving heat most rapidly, can be taken at three times that of the average. That is, for a portion of time we must assume the rate of burning will be twenty-four pounds of coal per square foot of grate per hour. We can estimate with the slow rate of average combustion assumed, and with adequate heating surface to the boiler, which surface shall be in good working order, both within and without, that there will be evaporated about nine pounds of water to each pound of coal consumed.

This gives a maximum rate of evaporation of two hundred and sixteen pounds of water per square foot of grate per hour, or 0·06 pounds of water per square foot of grate per second.

On the grounds stated in a preceding paragraph, we may neglect the increase of heat demanded for the evaporation of water at higher temperatures than 212°, and assume within our limits of twenty to one hundred and twenty pounds above the atmosphere, the weight of water evaporated or quantity of steam produced by the combustion of a given quantity of fuel to be constant.

Whatever error there is, from taking a larger quantity of steam at the higher pressures than is actually produced in the result, only adds to the dimensions of the safety-valve of such higher pressures, and is an error in a safe direction as well as a very small one.

When we come to the discussion of how great an allowance of excess of size over absolute requirement is to be made, we take first the coefficient of friction, as found by experiments on the flow of liquids through apertures and passages of a character similar to the passages of safety-valves: $A_0 = 1{\cdot}5\ a$ where A_0 is the area of absolute requirement sought, and a the sectional area of vein of fluid, supposing no resistance from the mouth of discharge to exist. And secondly, the practical coefficient employed to give adequate excess of area of valve for all contingencies.

This last has been taken at eight times the area of absolute requirement, or $A = 8\,A_0 = 12\,a$, where A is the area of the valve sought, and a as before, the values of A_0, A and a being taken in square inches.

The most simple equation expressing the relation of volumes of steam to water applicable to our purpose, is that given as the result of experiment by Fairbairn and Tate.

$$U_p = \frac{389}{P + 15{\cdot}052} + 0{\cdot}41,$$

where U_p = the volume of one pound steam in cubic feet, under any nominal pressure = P per square inch above the atmosphere. Whence we have

$$U = 0{\cdot}06 \left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41 \right) = \text{cubic feet of steam}$$

formed, under our supposition, per second.

The height of column to effect the discharge of steam under any pressure P (per square inch), is evidently equal to the volume of P pounds of steam multiplied by 144.

$$h = 144\,P \left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41 \right),$$

and the theoretical velocity of discharge in feet per second = $V = 8{\cdot}025\,\sqrt{h}$.

$$\therefore V = 8{\cdot}025 \sqrt{144\,P \left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41 \right)}.$$

The size of the vein a (in square feet), which will convey the volume U at the velocity V per second, is

$$a_1 = \frac{U}{v} = \frac{0{\cdot}06}{12 \times 8{\cdot}025} \sqrt{\frac{\frac{389}{P + 15{\cdot}052} + 0{\cdot}41}{P \left(\frac{389}{P + 15{,}052} + 0{\cdot}41 \right)}}$$

but $144\,a_1 = a$, and $12\,a = A$. $\therefore A = 1728\,a_1$.

$$\therefore A = \frac{1728}{12} \times \frac{0{\cdot}06}{8{\cdot}025} \sqrt{\frac{\left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41 \right)^2}{P \left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41 \right)}}$$

$$\therefore A = 21{\cdot}23 \sqrt{\frac{1}{P} \left(\frac{1}{P + 15{\cdot}052} + 0{\cdot}00105 \right)}.$$

We will now compare this with the legal formula of France, which reads

$$A \text{ (in centimetres)} = 0{\cdot}00053 \frac{S \text{ (in metres)}}{n - 0{\cdot}412},$$

where A = area of safety-valve, S = heating surface of boiler in square metres, and n = absolute pressure of steam in atmospheres. We can safely take the French practice in construction of their boilers at twenty units of boiler surface to each unit of grate-surface, as the boilers in general use in France assimilate in these ratios to those of our long cylinder or two-flued forms, when the proportions generally correspond. Substituting this value and taking 14·7 pounds for the atmospheric pressure, deducting one atmosphere of constant pressure, and reducing the whole to American weights and measures, we have—

$A = \frac{22{\cdot}5}{P + 8{\cdot}62}$, where A = area in square inches of safety-valve per square foot of grate-surface.

The results of the two formulas are given below:

Formula as calculated: $A = 21{\cdot}23 \sqrt{\frac{1}{P}\left(\frac{1}{P + 15{\cdot}052} + 0{\cdot}00105\right)}$.

Pressure in pounds per square inch		10	20	30	40	50	60	70	80	100	120
Area of safety-valve per square foot of grate	Square inches.	1·33	0·815	0·589	0·465	0·384	0·328	0·287	0·257	0·209	0·178

Formula as given in French law $A = \frac{22{\cdot}5}{P + 8{\cdot}62}$.

Pressure in pounds per square inch		10	20	30	40	50	60	70	80	100	120
Area of safety-valve per square foot of grate	Square inches.	1·21	0·786	0·583	0·461	0·384	0·328	0·286	0·254	0·207	0·175

This coincidence of result could only have existed from having the same basis, and the difference of form of the two second terms can only have arisen from the using some other and more tractable empirical formula for the volume of steam by those who originated the French rule.

The divergence below 20 pounds we do not consider essential, whether the calculated formula gives too large values, or the French one gives too small, and we would recommend for adoption the more simple formula $A = \frac{22{\cdot}5}{P + 8{\cdot}62}$.

It next remains to show the results of this formula when applied to practical cases, so as to see how nearly it is corroborated by the use of our American stationary boiler-makers.

We give tables of two pressures, 50 pounds and 80 pounds per square inch, and for areas of grates from 4 to 25 square feet of grate as below:

Areas of safety-valves for boilers with 80 pounds pressure (A = 0·254), and with grates of different dimensions.

Surface of grate in square feet	4	6	9	12	16	20	25
Estimated area of safety-valve	1	1·5	2·25	3	4	5	6·25
Estimated diameter of safety-valve in nearest whole numbers or quarters of inches	1¼	1½	1¾	2	2¼	2½	3

Areas of safety-valves for boilers with 50 pounds pressure (A = 0·384), and with grates of different dimensions.

Surface of grate in square feet	4	6	9	12	16	20	25
Estimated area of safety-valve	1·52	2·28	3·42	4·56	6·08	7·60	8·50
Estimated diameter of safety-valve in nearest whole numbers or quarters of inches	1¼	1¾	2¼	2¼	2¾	3¼	3¼

We think these dimensions correspond very nearly to the practice of all experienced constructors, and exhibit at once the usual size of safety-valve, and that of the main steam-pipe generally employed.

If we adopt the formula as expressing the proper areas of safety-valves for stationary boilers, which are not prepared to burn upon their grates more than eight pounds of coal per hour on the average, we have next to show how it can be applied to other conditions. With natural draft, the rapidity of combustion depends, in a great measure, upon the intensity of the fire, and a maximum rate of twenty-four pounds may, and probably does, accompany an average rate of eight pounds of coal per square foot of grate per hour, while with artificial draft or blast this rapidity of combustion is nearly independent of the condition of the fuel, and a maximum rate of twenty-four pounds will hardly be exceeded with an average one of sixteen. We think it safe to take this quantity of sixteen pounds average combustion per hour, with or by the aid of induced, or produced supply of air to the fuel (as with jets or by fans) as an equivalent to the one square foot of grate-surface, which we had taken as the unit of comparison with the area of the safety-valve.

That is, the area of one square foot of grate, *without* artificially

accelerated draft, may be assumed to require the same area of safety-valve, as the burning of sixteen pounds of coal per hour, *with* such draft, properly demands.

As regards those boilers which are heated by the waste heat of furnaces, or by the combustion of waste gases from some processes of manufacture, the circumstances are too variable to admit of statement in any law, and only the judgment of competent mechanics upon the performance of such boilers or steam-generators, can determine the proper area of safety-valves for them.

If the area given by the formula be applied to the opening of the seat of the safety-valve, it is obvious that the lift of the valve must be at least one-fourth the diameter, to have the same sectional area when open.

Hence, should any valves be so constructed that the range of motion will not admit, when fully raised, a lift equal to one-fourth the diameter of the opening of the seat of the valve, the sectional area actually given between the raised valve and the edge of the valve-seat should be taken as that to which the rule applies.

And while the formula gives areas abundantly large to meet the general resistance to discharge, which proceeds from the necessary form of a disk resting upon, or placed in proximity to, a seat, we think we ought here to state, that it is always advisable that the undersides of safety-valve disks should have a globular or pointed form (whether with or without guide-wings), and not be made flat as they sometimes are, and that the disks be beveled-edged, resting upon a very narrow beveled seat and do not have a flat bearing. It may be well to state, also, that, as ordinarily constructed, a safety-valve, after lifting and allowing a flow of steam all around the disk, does not continue to raise and allow all the steam, as formed, to escape at the constant pressure, but admits some elevation of pressure before opening wide. With the areas given by the formula, and where the disks have been shaped as we have before described, this increase of pressure will not exceed 10 per cent. of the initial load on the valve, and the additional resistance to opening is a safeguard against the too sudden relief of steam, to the derangement of the water circulation of the boiler.

The Committee will only add, as regards further consideration of the form or description of safety-valves, and as to legal requirements beyond the adequacy of the openings, that the subject becomes too extensive for them to consider.

As originally made in the days of Watt, almost as planned by

Papin, the essential parts of the safety-valve have substantially remained until this time. No patent covers its simplicity or improves its certainty, although there have been made and used a thousand kinds, and there are a hundred existing patents.

It can only be imperfect by palpable misconstruction, or unsafe by vicious intent, and we can only recommend the defects to competent inspection with power to remedy, and the misuse to the punishment of the law. There is very little likelihood that a safety-valve, properly constructed and in proper hands, would get out of order or fail to act at the needed moment. But, on the supposition that such catastrophe might occur, it has been thought by the Committeee, after much deliberation, that, in order to divide the small chance for failure, it may be as well to make it a legal requirement, that in place of one safety-valve, each and every boiler shall have at least two, the aggregate area of which should be that established by the formula.

These valves ought to be loaded with the same load, and blow-off indiscriminately, so that either or both may be in action at once.

This plan would call for, and ensure, more care in graduating the loads on safety-valves than is at present employed. The Committee feel justified in observing that there are now in use more safety-valves improperly graduated or marked, than there are those imperfectly or unsuitably constructed. Lock-up safety-valves are but little protection from fraud or over-pressure, and less security, unless frequently tested, and their use is decidedly discountenanced by the Committee.

We conclude our discussion of this branch of the subject committed to us, by recommending for the approval of the Institute, the following

SCHEDULE,

Giving the least aggregate area of safety-valves (being the least sectional area for the discharge of steam) to be placed upon all stationary boilers with natural or chimney draft.*

This area may be expressed by the formula—

$$A = \frac{22{\cdot}49}{P + 8{\cdot}62},$$

in which A = area of combined safety-valves in square inches.
G = surface of grate in square feet.†

---

* Where boilers have a forced or artificial draft, the combustion of 16 pounds of coal per hour should be taken as equivalent to the 1 square foot of grate surface = G in the above formula and table.

$P = \left\{ \begin{array}{l} \text{pressure of steam in pounds per square inch to be} \\ \text{carried in the boiler above the atmosphere.} \end{array} \right.$

The following table gives the results of the formula for one square foot of grate as applied to boilers used at different pressures.

Pressures in pounds per square inch.....	10	20	30	40	50	60	70	80	90	100	120
Areas in square inches corresponding to each square foot of grate.....	1·21	0·79	0·58	0·46	0·38	0·33	0·29	0·25	0·23	0·21	0·17

We give one example of the application of the figures given by the table—

Suppose the boiler to work under 60 pounds pressure, then each square foot of grate-surface should have an area of safety-valve by the table of } = 0·33 square inches.

Suppose the boiler to leave 25 square feet of grate-surface, } = 25

giving a calculated area for the safety-valves = 8·33 square inches.

This would call for two safety-valves, each having an area of 4·16 square inches, or a diameter of $2\frac{3}{10}$ths inches.

And the Committee would report on the second branch of the subject referred to them,—the legal requirements which ought to be made as to pressure-gauges, that the time allotted to them has not permitted a complete investigation. The great advantage which any of these instruments possess, is found in their indicating the pressure of steam within a boiler, so as to allow a fireman to regulate his supply of fuel with economy. There are many kinds and forms of gauges, almost every one of which has some characteristic superiority over all, or most other kinds and forms, but we do not wish to say that any of them are perfectly or permanently reliable.

And your Committee would ask to be relieved from further consideration of the subjects referred to them.

ROBERT BRIGGS,
COLEMAN SELLERS,
J. VAUGHAN MERRICK,
WM. BARNET LE VAN.

† Where boilers are heated by the waste heat of furnaces, or otherwise than by fire upon grates, the value to be taken for G must be estimated by some competent person, based upon the comparative performance of boilers with others heated in the usual way.

Bibliographical Notices.

Review of Lecture-Notes for Chemical Students. By Edward Frankland, F. R. S., Professor of Chemistry in the Royal Institution of Great Britain.

One of the most noteworthy scientific works which has been issued by the English press during the past year, is the Lecture-Notes for Chemical Students, by Prof. Frankland. It is written in the spirit in which Hoffmann, Gerhardt, Williamson, and the long array of innovators in chemical science, have conceived and executed their researches, and is an ably executed endeavor to put into the hands of the student, a text-book according to the latest theories of chemistry. In assigning to the elements their atomic weights, the *specific heat* of atoms is made a consideration of fundamental importance. Besides two other conditions, the "atomic weight is made to represent, as far as possible, the weight of the element in the solid condition, which at any given temperature contains the same amount of heat, as seven parts by weight of solid lithium at the same temperature." The above condition is not new, but embodies the general conclusion which was arrived at by Dulong and Petit, in their researches upon the specific heat of atoms—that all elementary atoms have the same capacity for heat, and that all atomic weights should be made to accord with this supposition. This conclusion is experimentally true for lead, zinc, copper and many other elements, but does not hold good for arsenic and silver, which have twice the capacity for heat as the class above named, nor in the case of phosphorus, which has four times, and in some other instances. The difficulty has hitherto been, that if such atomic weights are taken as would have the same specific heat as the atomic weight of the element, which is selected as a standard of comparison, the atomic weight of phosphorus would require to be divided by four, while that of arsenic, which is the next of kin to phosphorus in all its chemical properties, would be divided by two only. In the table of elements, however, which is given in the work under review, no attempt has been made to bring the atomic weights of phosphorus, arsenic and some others into accordance with the rule.

Moreover, the atomic weights of oxygen, sulphur, selenium, carbon and many others are doubled, in order to satisfy another condition, which is "that the atomic weight is made to represent, as far as pos-

sible, the weight of the element, which, in the form of gas or vapor, occupies, under like conditions of temperature and pressure, the same volume as one part by weight of hydrogen." According to this rule, the atomic weights of phosphorus and arsenic would be twice their accepted atomic weights, or 62 and 150; but in the appended table they are given as 31 and 75, and these discrepancies, like the foregoing, are admitted as irreconcilable in the present state of chemical science.

The distinction between *atoms* and *molecules* is invested with great significance, the former term being applied, according to present usage, to that amount of an element which is represented by its atomic weight, and the latter to the smallest amount which can exist in an uncombined state. It is found, for example, that the molecule of hydrogen, oxygen and chlorine, consists of two atoms of each element, and it is accordingly termed a diatomic molecule. A list is given of those elements whose molecular condition has been determined, according to which the molecules of bromine, iodine, fluorine, nitrogen, sulphur and selenium, consist likewise of two atoms, or are diatomic. The molecules of mercury, cadium and zinc contain but one atom, and are accordingly termed *monatomic*. The molecule of oxygen, in the condition of ozone, is *triatomic*. Phosphorus and arsenic, *tetratomic*, and sulphur, to which, as well as to oxygen, two distinct molecular weights are accorded, is *hexatomic*.

The most striking feature of the book is the prominence which is given to the *atomicity* of elements. By this new term in chemistry is meant, the relative powers of the atoms of different elements to combine with, or displace from, combinations, the atoms of other elements. It is also called their atom-fixing and atom-displacing power, or their *quantivalence*. One atom of chlorine, for example, is equivalent to one atom of hydrogen, since it can be substituted for it in combination. The atomicity of chlorine or its quantivalence, is therefore taken as one, and chlorine and other elements, like fluorine, bromine, potassium, silver, having also an atomicity of one, are called *monads*. In like manner, one atom of oxygen or zinc can be substituted for two atoms of hydrogen, one atom of boron for three atoms of hydrogen, one atom of carbon for four, one of nitrogen for five, and one atom of sulphur for no less than six atoms of hydrogen. The atoms are represented by circles surrounding the symbols of the elements, and the atomic structure of bodies is illustrated by a very large number of drawings, which are of value to the student, whether his views agree with those of the author or not. A. R. L.

A COMPARISON *of some of the Meteorological Phenomena of* SEPTEMBER, 1867, *with those of* SEPTEMBER, 1866, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11½′ W. from Greenwich. By PROFESSOR J. A. KIRKPATRICK, of the Central High School.

	September, 1867.	September, 1866.	September, for 17 years.
Thermometer—Highest—degree	86·00°	91·00°	95·00°
" date	19th.	3d.	12th, '56.
Warmest day—mean	77·83	82·00	85·20
" " date	6th.	2d.	6th, '54.
Lowest—degree	43·00	50·00	39·00
" date	30th.	22d & 23d.	25th, '56.
Coldest day—mean	50·00	57·17	50·00
" " date	30th.	22d & 23d.	30th, '67.
Mean daily oscillation	14·52	14·30	15·97
" " range	5·36	4·97	4·74
Means at 7 A. M.	63·12	65·13	63·26
" 2 P. M.	73·62	75·65	74·61
" 9 P. M.	66·80	68·22	67·06
" for the month	67·84	69·67	68·31
Barometer—Highest—inches	30·466	30·155	30·466
" date	24th.	16th.	24th, '67.
Greatest mean daily pressure	30·392	30·101	30·392
" " " date	24th.	16th.	24th, '67.
Lowest—inches	29·623	29·520	29·281
" date	29th.	21st.	18th, '63.
Least mean daily pressure	29·726	29·608	29·403
" " " date	29th.	12th.	16th, '58.
Mean daily range	0·136	0·133	0·122
Means at 7 A. M	30·084	29·842	29·958
" 2 P. M	30·050	29·786	29·916
" 9 P. M	30·058	29·828	29·939
" for the month	30·064	29·819	29·938
Force of Vapor—Greatest—inches	0·812	0·864	0·991
" date	17th.	2d.	6th, '54.
Least—inches	·125	·243	·125
" date	30th.	23d.	30th, '67.
Means at 7 A. M	·485	·530	·480
" 2 P. M	·531	·562	·503
" 9 P. M	·528	·585	·520
" for the month	·514	·559	·501
Relative Humidity—Greatest—per cent	95·0	95·0	100·0
" date	3d & 5th.	20th & 26th.	2d, '54.
Least—per cent	28·0	46·0	28·0
" date	30th.	22d.	30th, '67.
Means at 7 A. M	80·2	81·3	78·4
" 2 P. M	61·4	61·1	57·0
" 9 P. M	76·9	81·8	74·7
" for the month	72·8	74·7	70·0
Clouds—Number of clear days*	11·	7·	10·8
" cloudy days	19·	23·	19·2
Means of sky covered at 7 A. M	66·3 per ct	74·3 per ct	58·6 per ct
" " " 2 P. M	49·3	50·7	52·2
" " " 9 P. M	41·7	52·0	37·2
" " for the month	52·5	59·0	49·4
Rain—Amount—inches	1·850	7·457	4·289
No. of days on which rain fell	7·	11·	8·3
Prevailing Winds—Times in 1000	N69°46′W·125	N47°17′W·105	N89°45′W·175

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LIV.] DECEMBER, 1867. [No. 6.

EDITORIAL.

In the January number of this *Journal* for the present year, the Editor and Committee on Publications, announced to their readers certain alterations which they proposed to make, and asked for that co-operation by which such changes could most fully effect their primary object, namely, the extension of our circulation, and therefore of the general diffusion of useful knowledge and the excitement of interest in those scientific and practical studies which it is our special object to foster, and which so eminently tend to aid the growth and improvement of an energetic nation.

It seems appropriate, therefore, that in this our final number for the year, we should say a few words as to the success which has attended our efforts, aided as they have been by able and effective co-operation from many sources.

With reference to the course laid out and consistently followed as regards the subject-matter of this *Journal*, we may say, that experience has in all respects corroborated our opinion that practical infor-